# DESCRIPTIONS OF NEW CRETACEOUS AND TERTIARY FOSSILS FROM THE SANTA CRUZ MOUNTAINS, CALIFORNIA.

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## INTRODUCTION.

During the past seventeen years the professors and students in the geologic department of Leland Stanford Junior University have brought together from the Santa Cruz Mountains and adjacent regions a large lot of paleontological material which is now the property of the university. In addition to this the writer has made extensive collections in the same region for the United States Geological Survey. All of this material is now being worked over by the writer for a monograph on the paleontology of the Santa Cruz quadrangle, within the boundaries of which the greater part of the Santa Cruz Range lies. The Santa Cruz folio, embracing maps, geologic sections, a plate of the characteristic or common fossils of the region, and text devoted to a description of the geology of the quadrangle, is now ready for the press. Many of the species of fossils figured on the folio plate are new, and in order to avoid the confusion in nomenclature which might arise should this folio (which is written jointly by J. C. Branner, J. F. Newsom, and Ralph Arnold) be published before the appearance of the monograph describing the fossils, it has been deemed expedient to prepare the present preliminary paper describing those of the new species which are figured in the folio. A list of some of the previously described species associated with the new forms will be included in this report, together with a brief description of the various formations from which the fossils have been obtained, to make clearer the relations of the faunas involved. A few of the old species will also be figured for the same reason.

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## GEOLOGIC FORMATIONS.

*General statement.*—There are thirteen distinct formations involved in the geology of the Santa Cruz quadrangle. Of these the oldest is the basement complex of granitic rocks, schists, and limestone. Above these are the Franciscan, probably of upper Jurassic age; Knoxville, lower Cretaceous; Chico, upper Cretaceous; undifferentiated Eocene, probably representing the lower part of this epoch; probable lower Oligocene sandstone and San Lorenzo formation, Oligocene; Vaqueros, lower Miocene; Monterey, middle Miocene; Santa Margarita, upper Miocene; Purisima, upper Miocene to middle Pliocene; Merced, marine upper Pliocene and Pleistocene; fresh water upper Pliocene and Pleistocene, and Quaternary.

## CRETACEOUS.

*Knoxville formation, lower Cretaceous.*—The beds of Knoxville age in the Santa Cruz Mountains are made up of conglomerate, sandstone, and shale. They cover only small areas in the Santa Cruz quadrangle and are confined entirely to the northeastern or Santa Clara Valley side of the mountain range. The fauna is small but very characteristic, and contains species that are usually found at the fossiliferous localities of the Knoxville in other parts of the State. The fauna of this formation as represented in the Santa Cruz quadrangle is as follows:

*List of Knoxville, lower Cretaceous, fossils from the Santa Cruz quadrangle.*

PELECYPODA.

*Aucella crassicollis* Keyserling.

*Aucella piochii* Gabb.

GASTEROPODA.

*Amberlya dilleri* Stanton.

CEPHALOPODA.

?*Hoplites*, species.

*Chico formation, upper Cretaceous.*—The only fossiliferous Chico rocks exposed in the quadrangle extend along the coast from near the mouth of Pescadero Creek southward to Año Nuevo Bay, a distance of 12 miles. This area varies in width from one-half to 2½ miles, and is at places covered partially by a thin layer of Quaternary gravels and sands. The Chico strata along the coast are made up for the most part of hard siliceous shales, sandstones, and massive, coarse conglomerate. The total thickness exposed is believed to be about 9,400 feet. The strata dip at high angles, and have been sharply folded and faulted in places, thereby making the thickness appear greater than it is. Areas of supposed Chico are found in the low hills west of Redwood and west of Stanford University, but no important faunas have been obtained from these exposures. The Chico beds in the vicinity of Pigeon Point have yielded the following species:

*List of Chico, upper Cretaceous, fossils from the Santa Cruz quadrangle.*

PELECYPODA.

*Anatina tryoniana* Gabb.
*Arca vancouverensis* Meek.
*Cucullæa bowersiana* Cooper.
*Glycymeris veatchii* (Gabb).
*Inoceramus subundatus* Meek.
*Mactra stantoni*, new species.
*Nucula truncata* Gabb.
*Ostrea brewerii* (?) Gabb.
*Panopea concentrica* Gabb.
*Pholadomya subelongata* Meek.
*Pinna calamitoides* Shumard.
*Trigonia evansiana* Meek.
*Trigonia leana* Gabb.

GASTROPODA.

*Cinulia obliqua* Gabb.
*Lunatia*, new species, *p.*
*Margaritella*, new species, *a.*
*Perissolax brevirostris* Gabb.
*Turritella pescaderoensis*, new species.

CRUSTACEA.

*Archæopus antennatus* Rathbun.

TERTIARY.

*Undifferentiated Eocene.*—The diabase dike exposed north of the headwaters of Pescadero Creek has brought up some considerable inclusions of impure limestone which, from the fossils found in them, appear to be of Eocene age. Obviously the stratigraphic relations of this great limestone inclusion are unknown, but the fossils indicate its Eocene age and that it probably belongs in the lower part of the formation. The following fauna occurs in this limestone:

*List of lower Eocene fossils from the Santa Cruz quadrangle.*

ECHINOIDEA.

*Cidaris merriami*, new species.

BRACHIOPODA.

*Terebratalia*, new species, *m.*
*Terebratalia*, new species, *p.*
*Terebratulina tejonensis* Stanton.

PELECYPODA.

*Pecten proavus* Arnold.
*Semele gayi*, new species.

GASTEROPODA.

*Chlorostoma*, new species, *c.*
*Cylindrites brevis* (?) Gabb.
*Fissurella perrini*, new species.
*Hipponyx carpenteri*, new species.
*Odostomia*, new species, *b.*
*Patella*, new species, *b.*
*Patella mateoensis*, new species.
*Thylacodes*, new species, *w.*
*Tritonium newsomi*, new species.

## OLIGOCENE.

*Probable lower Oligocene sandstone.*—This formation is composed of medium to coarse-grained massive brown and buff sandstone, and outcrops in a triangular area, the eastern portion of which is at the San Lorenzo River 4 miles north of the town of Boulder Creek. It attains a maximum thickness of at least 2,100 feet, and as the base of this section was not exposed it is probably some thicker. The formation conformably underlies the San Lorenzo shale, but its base is unknown, unless it is represented by the upper member of the unconformity exposed immediately south of the mouth of Pescadero Creek. No fossils have been found in the main area of the formation, but the outcrop near the mouth of Pescadero Creek has yielded several forms, among which are *Pecten*, closely allied to *P. sanctæcruzensis* Arnold, a fragment of a huge *Venericardia*, a large *Turritella*, and an echinoderm suggesting *Clypeaster.*

*San Lorenzo formation.*—The San Lorenzo formation, within the limits of the Santa Cruz quadrangle, is characteristically of shale and fine sand. It outcrops in the region north of Ben Lomond Mountain and between the latter and Castle Rock Ridge, its areal distribution being controlled by the northwest-southeast folds which are the prominent structural features of this portion of the quadrangle. The formation attains a maximum thickness of about 2,500 feet on Kings Creek. The most abundantly fossiliferous localities are on the San Lorenzo River, Kings Creek, and Two Bar Creek, and also along the south side of the Big Basin. The following fauna has been obtained from the San Lorenzo in various parts of the Santa Cruz quadrangle:

*List of San Lorenzo, Oligocene, fossils from the Santa Cruz quadrangle.*

### ECHINOIDEA.

*Cidaris branneri*, new species.

### PELECYPODA.

*Cardium cooperi* Gabb, var. *lorenzanum*, new variety.
*Cardium*, species, *a.*
*Leda*, new species, *s.*
*Lithophaga*, species, *a.*
*Malletia chehalisensis*, new species.
*Modiolus ynezianus* Arnold.
*Mulinia*, (?) species, *a.*
*Neæra*, new species, *a.*
*Nucula dalli*, new species.
*Pecten peckhami* Gabb.
*Pecten sanctæcruzensis* Arnold.
*Phacoides*, species, *a.*
*Solen*, species, *a.*
*Tellina albaria* Conrad.
*Tellina lorenzoensis*, new species.
*Tellina*, new species, *a.*
*Yoldia impressa* Conrad.

### GASTEROPODA.

*Actæon*, species, A.
*Architectonica lorenzoensis*, new species.
*Dentalium*, new species, *l.*
*Dentalium substriatum* Conrad.
*Fusus corpulentus* Conrad.
*Fusus geniculus* Conrad.
*Fusus hecoxi*, new species.

*Fusus sanctæcrucis*, new species.
*Galerus excentricus* (?) Gabb.
*Haminea petrosa* Conrad.
*Lunatia*, new species, *l*.
*Natica oregonensis* Conrad.
*Lirofusus ashleyi*, new species.
*Pleurotoma*, new species, *a*.
*Pleurotoma*, new species, *b*.
*Pleurotoma newsomi*, new species.
*Pleurotoma perissolaxoides*, new species.
*Pleurotoma sanctæcrucis*, new species.
*Scala*, species, A.
*Sigaretus scopulosus* Conrad.
*Strepsidura californica*, new species.
*Turcicula sanctacruzana*, new species.

### CEPHALOPODA.

*Aturia ziczac* Sowerby.

*Transitional Oligocene-Miocene.*—The fine massive sandstones on Twobar Creek lying above the typical San Lorenzo (Oligocene) shales, but below the Vaqueros (lower Miocene) sandstone and conglomerate, contain a fauna allied to those of both the beds below and the beds above. The fauna, however, appears to be more closely related to that of the San Lorenzo. Among the species common to the latter and to the transitional beds are: *Cardium cooperi* Gabb, *var. lorenzanum*, new variety; *Marcia oregonensis* Conrad; *Tellina lorenzonesis*, new species; *Pecten sanctæcruzensis* Arnold; *Solen*, species; *Yoldia impressa* Conrad; *Sigaretus scopulosus* Conrad, etc. Those common to the transitional beds and the Vaqueros (lower Miocene) are: *Marcia oregonensis* Conrad; *Chione* (*cf.*) *mathewsonii* Gabb; *Pecten branneri* Arnold; *Thracia trapezoides* Conrad; *Tritonium*, species, etc.

### MIOCENE.

*Vaqueros sandstone.*—The Vaqueros sandstone of lower Miocene age is one of the most important formations of the quadrangle. Its areal distribution is controlled largely by the northwest-southeast structural lines usual in the quadrangle, and the areas covered by it therefore consist for the most part of northwest-southeast bands.

The sandstone varies in texture from fine-grained beds to conglomerate, but are usually medium-grained and generally brown or buff in color, and vary from soft to extremely hard. The Vaqueros lies conformably above the San Lorenzo formation, and there is often a gradual change from one formation to the other, with no clear line of demarcation between them. But while the San Lorenzo formation is made up chiefly of shales and fine-grained, impure sandstones, the Vaqueros formation is composed principally of medium and coarse-grained sandstones, showing that the conditions of deposition were different during the two periods.

The relation of the Vaqueros sandstone to the overlying beds is not so clear as are its relations to the underlying strata. There is an unconformity west of a part of the Big Basin area between the diatomaceous shale (supposed to be Monterey) and the underlying San Lorenzo formation; the latter formation lies conformably below the Vaqueros sandstone. Elsewhere in the quadrangle there is commonly a marked difference in the dips of the Monterey strata and those of the Vaqueros sandstone, and an unconformity is therefore believed to exist generally between the two formations.

Few localities in the Vaqueros sandstone are fossiliferous, but such as are yield an abundant fauna of unmistakable lower Miocene age. As would be expected in a formation composed largely of conglomerates and coarse sandstones, the Vaqueros contains a shallow water or littoral fauna.

The following species have been found in the Vaqueros formation within the Santa Cruz quadrangle:

BRACHIPODA.

*Terebratalia (aff.) occidentalis* Dall.

PELECYPODA.

*Arca microdonta* Conrad.
*Callista*, species, *v.*
*Cardium vaquerosensis*, new species.
*Chione temblorensis* Anderson.
*Dosinia conradi* Gabb.
*Dosinia mathewsonii* Gabb.
*Dosinia cf. montana* Conrad.
*Dosinia ponderosa* Gray.
*Glycymeris branneri*, new species.
*Leda cahillensis*, new species.
*Ostrea titan* Conrad, new variety, *v.*
*Panopea generosa* Gould.
*Pecten andersoni* Arnold.
*Pecten branneri* Arnold.
*Pecten estrellanus* Conrad
*Pecten magnolia* Conrad.
*Phacoides richthofeni* Gabb.
*Phacoides acutilineatus* Conrad.
*Pinna alamedensis* Yates.
*Psammobia edentula* Gabb.
*Solen*, species, *v.*
*Tivela ineziana* Conrad.
*Yoldia submontereyensis*, new species.

GASTEROPODA.

*Actæon*, species, *v.*
*Agasoma kernianum* Cooper.
*Agasoma santacruzana*, new species.
*Conus oweniana* Anderson.
*Crepidula princeps* Conrad.
*Cuma biplicata* Gabb.
*Galerus inornatus* (?) Gabb.
*Macron*, species, *v.*
*Neverita callosa* Conrad.
*Olivella*, species, *v.*
*Phos*, new species, *v.*
*Sigaretus scopulosus* Conrad.
*Turritella ineziana* Conrad.
*Turritella ocoyana* Conrad.

PISCES.

*Galeocerdo productus* Agassiz.
*Lamna clavata* Agassiz.

*Monterey shale.*—As with the previously described Tertiary formations, the areal distribution of the Monterey is controlled largely by the northwest-southeast structural lines of the region.

The largest area of Monterey shale on the quadrangle is that flanking the west side of the Santa Cruz Range and extending from the city of Santa Cruz northwestward for 30 miles to a point slightly north of Pescadero Creek. At the base of the shale through most of this region is a body of sandstone, varying in thickness from 50 to 200 or 300 feet. The maximum thickness of the Monterey for the quadrangle is about 2,500 feet, The formation consists chiefly of diatomaceous shale, with here and there intercalated sandstones. The diatomaceous material occurs in various grades of purity, from the very light shales composed almost entirely of diatom skeletons to those containing such large proportions of clay and fine sands as to almost or quite lose their diatomaceous character. In the region northwest of Santa Cruz and in many other places in the Coast ranges the Monterey shale is ordinarily spoken of as "chalk rock." The shale usually weathers to white or buff color, but unweathered surfaces often present a dark gray, drab, or chocolate color.

The paucity of marine invertebrate fossils in the formation is one of its characteristics, although the rather widespread distribution of two of its species, *Pecten peckhami* Gabb and *Arca obispoana* Conrad, is important.

The following species have been found in the Monterey at various points throughout the quadrangle:

*List of Monterey, middle Miocene, fossils in the Santa Cruz quadrangle.*

ECHINOIDEA.

*Cidaris*, species, *a*.

PELECYPODA.

*Arca obispoana* Conrad.
*Chione mathewsonii* Gabb.
*Corbula*, species, *a*.
*Diplodonta* (*aff.*) *serricata* Reeve.
*Mactra montereyana*, new species.
*Marcia oregonensis* Conrad.
*Pecten andersoni* Arnold.
*Pecten peckhami* Gabb.
*Semele*, species, *a*.
*Siliqua*, species, *a*.
*Tellina congesta* Conrad.
*Venericardia montereyana*, new species.
*Yoldia impressa* Conrad.

GASTEROPODA.

*Haminea petrosa* Conrad.

*Santa Margarita formation.*—The region of Scott Valley north of Santa Cruz is occupied by a formation showing some very distinctive characteristics. The base of this formation, which in places rests unconformably on the Monterey, consists of about 200 feet of coarse, white, incoherent sand with bedded conglomerates near the bottom. Above the white sand is a thickness of about 100 feet of fine, thin-bedded, rather hard shale, which in the Scott Valley region lies nearly horizontal.

Few fossils have been found in either the sandstone or shale of this formation, but the lithologic similarity of the beds to those of the Santa Margarita formation of the Salinas Valley, together with the identity of those species of fossils which have been obtained from the Santa Margarita in the Santa Cruz region, has led to the correlation of the latter with the typical Santa Margarita farther south.

The following species have been found in the Santa Margarita formation within the quadrangle:

*List of Santa Margarita, upper Miocene, fossils from the Santa Cruz quadrangle.*

### ECHINOIDEA.

*Astrodapsis antiselli* Conrad.

### OPHIUROIDEA.

*Amphiura sanctaecrucis* Arnold.

### PELECYPODA.

*Pecten crassicardo* Conrad.

## TRANSITIONAL MIOCENE-PLIOCENE.

*Purisima formation.*—A large portion of the Santa Cruz quadrangle is occupied by an apparently continuous series of sediments composed of heavy conglomerates, sandstones, breccias, impure soft mud shales, and white diatomaceous shale like the Monterey shale. The formation as here defined attains a maximum thickness of bebetween 5,000 and 8,000 feet, and includes a thick mass of sediments representing upper Miocene and much of Pliocene time. They appear to be conformable, and no area was found where they could be conveniently subdivided.

The Purisima beds lie unconformably upon the Vaqueros sandstone and are usually unconformable above the Monterey shale; upward they grade into beds having a fauna similar to that of the Merced formation. The upper limit of the Purisima may be defined as the base of the Merced, as exposed in the type section of Merced on Seven-mile Beach south of San Francisco and north of the Santa Cruz quadrangle.

Overlying the Miocene basalt in the region south and southwest of Stanford University are some fossiliferous beds which have been mapped with the Purisima but which are probably older than any of the Purisima in the type region.

The fauna yielded by these beds, which are believed to be the equivalent of what Merriam has called the "Contra Costa County Miocene," is as follows:

*List of fossils from the lower part of the Upper Miocene of the Santa Cruz quadrangle.*

### PELECYPODA.

*Arca (cf.) obispoana* Conrad.
*Arca canalis* Conrad.
*Chione (cf.) temblorensis* Anderson.
*Chione mathewsonii* Gabb.
*Dosinia mathewsonii* Gabb.
*Dosinia ponderosa* Gray.
*Leda taphira* Dall.
*Panopea generosa* Gould.
*Phacoides acutilineatus* Conrad.
*Pecten andersoni* Arnold.
*Periploma sanctaecrucis*, new species.
*Saxidomus (cf.) gibbosus* Gabb.
*Solen sicarius* Gould.
*Spisula (cf.) californica* Conrad.
*Tapes (cf.) staleyi* Gabb.
*Yoldia supramontereyensis*, new species.

GASTEROPODA.

*Agasoma kernianum* Cooper.
*Fissuridea*, species, *a*.
*Fusus stanfordensis*, new species.
*Galerus inornatus* Gabb.
*Megatebennus (cf.) bimaculatus* Dall.
*Natica (cf.) ocoyana* Conrad.
*Trochita costellata* Conrad.

A second fossiliferous horizon, believed to be somewhat younger than the last, is represented by the fauna found in Pescadero Creek near the mouth of Jones Gulch and on the Halliday ranch near Portola. The fauna from the middle part of the formation is as follows:

*List of fossils from the lower portion of the Purisima formation.*

PELECYPODA.

*Arca canalis* Conrad.
*Arca trilineata* Conrad.
*Cardium meekianum* Gabb.
*Chione (aff.) gnidia* Broderip and Sowerby.
*Clidiophora punctata* Conrad.
*Cryptoma ovalis* Conrad.
*Dosinia ponderosa* Gray.
*Macoma nasuta* Conrad.
*Mactra albaria* Conrad.
*Nucula (Acila) castrensis* Hinds.
*Panopea generosa* Gould.
*Pecten healeyi* Arnold.
*Pecten oweni* Arnold.
*Pecten purisimaensis* Arnold.
*Pecten wattsi* Arnold.
*Phacoides acutilineatus* Conrad.
*Phacoides nuttalli* Conrad, var. *antecedens* Arnold.
*Solen sicarius* Gould.
*Tapes staleyi* Gabb.
*Tellina*, new species, *a*.
*Venus pertenuis* Gabb.

GASTEROPODA.

*Chlorostoma stantoni* Dall, var. *lahondaensis*, new variety.
*Chrysodomus imperialis* Dall.
*Chrysodomus (aff.) liratus* Martyn.
*Chrysodomus stantoni*, new species.
*Crepidula princeps* Conrad.
*Fusus portolaensis*, new species.
*Lunatia lewisii Gould.*
*Nassa californiana* Conrad.
*Natica clausa* Broderip and Sowerby.
*Neptunea (aff.) humerosa* Gabb.
*Olivella intorta* Carpenter.
*Olivella pedroana* Conrad.
*Pleurotoma*, species, *a*.
*Solariella (aff.) peramabilis* Carpenter.
*Thais crispata* Chemnitz.
*Tornatina culcitella* Gould.
*Tritonium*, species, *a*.

The upper part of the Purisima formation usually consists of fine soft sandstone with harder calcareous and often fossiliferous beds intercalated. These upper beds are typically exposed in the sea cliffs in the vicinity of Purisima and south to the mouth of Pescadero Creek, in the region immediately east of Point Ano Nuevo and in the region east of Santa Cruz.

The following fossils occur in the upper portion of the Purisima formation:

*List of fossils from the upper portion of the Purisima formation, Santa Cruz quadrangle.*

ECHINOIDEA.

*Astrodapsis*, new species, *p*.

### PELECYPODA.

*Arca canalis* Conrad.
*Arca trilineata* Conrad.
*Cardium meekianum* Gabb.
*Cryptomya ovalis* Conrad.
*Leda taphria* Dall.
*Macoma nasuta* Conrad.
*Mactra albaria* Conrad.
*Modiolus directus* Dall.
*Moerella salmonea* Carpenter.
*Nucula (Acila) castrensis* Hinds.
*Panomya*, species, *a*.
*Panopea generosa*, Gould.
*Pecten healeyi* Arnold.
*Pecten hastatus* Sowerby.
*Pecten purisimaensis* Arnold.
*Pecten nutteri* Arnold.
*Phacoides annulatus* Reeve.
*Phacoides nuttalli* Conrad.
*Saxidomus gibbosus* Gabb.
*Schizothærus pajaroanus* Conrad.
*Siliqua (cf.) lucida* Conrad.
*Siliqua (cf.) patula* Dixon.
*Spisula (cf.) sisquocensis* Arnold.
*Tapes staleyi* Gabb.
*Tapes tenerrima* Carpenter.
*Tellina (aff.) congesta* Conrad.
*Thracia trapezoides* Conrad.
*Yoldia cooperi* Gabb.
*Yoldia (aff.) scissurata* Dall.
*Zirphæa gabbi* Tryon.

### GASTEROPODA.

*Admete gracilior* Carpenter.
*Astyris richthofeni* Gabb.
*Bathytoma carpenteriana* Gabb, var. *fernandoana* Arnold.
*Bittium asperum* Gabb.
*Boreotrophon pacificus* Dall.
*Cancellaria*, species, *a*.
*Chrysodomus stantoni*, new species.
*Chrysodomus tabulatus* Baird.
*Crepidula princeps* Conrad.
*Crepidula navicelloides* Nuttall.
*Drillia (aff.) graciosana* Arnold.
*Galerus inornatus* Gabb.
*Leptothyra paucicostata* Dall.
*Lunatia lewisii* Gould.
*Miopleiona oregonensis* Dall.
*Nassa californiana* Conrad.
*Nassa (aff.) perpinguis* Hinds.
*Natica clausa* Broderip and Sowerby.
*Neverita recluziana* Petit.
*Olivella intorta* Carpenter.
*Olivella pedroana* Conrad.
*Priene pacifica* Dall.
*Serpulorbis squamigerus* Carpenter.
*Sigaretus debilis* Gould.
*Voluta*, new species, *a*.

## PLIOCENE.

*Merced formation.*—The Merced formation, so remarkably developed at Sevenmile Beach, south of Lake Merced, only a few miles north of the Santa Cruz quadrangle, is barely represented on the latter. Certain limited fossiliferous outcrops, however, yield a fauna similar to that of the typical Merced and have therefore been correlated with it. The most important of these localities are just south of the mouth of Año Nuevo Creek, near Felt Lake, and in the sea cliffs between Santa Cruz and Capitola. The following species of fossils have been found in the Merced outcrops above indicated:

*List of Merced (upper Pliocene) fossils from the Santa Cruz quadrangle.*

### ECHINOIDEA.

*Scutella interlineata* Simpson.

### PELECYPODA.

*Arca canalis* Conrad.
*Arca trilineata* Gabb.
*Cardium meekianum* Gabb.
*Chione*, species, A.
*Cryptomya californica* Conrad.
*Macoma nasuta* Conrad.
*Mactra albaria* Conrad.
*Modiolus directus* Dall.
*Nucula castrensis* Hinds.
*Pecten latiauritus* Conrad.
*Siliqua patula* Dixon.
*Solen sicarius* Gould.
*Tapes staleyi* Gabb.

### GASTEROPODA.

*Astyris richthofeni* Gabb.
*Chrysodomus stantoni*, new species.
*Crepidula princeps* Conrad.
*Littorina*, species.
*Lunatia lewisii* Gould.
*Margarita pupilla* Gould.
*Nassa californiana* Conrad.
*Nassa mendica* Gould.
*Nassa perpinguis* Hinds.
*Olivella biplicata* Sowerby.
*Olivella intorta* Carpenter.
*Olivella pedroana* Conrad.
*Thais ostrina* Gould.
*Thais trancosana*, new species.

*Fresh-water Pliocene-Pleistocene.*—During at least a portion of the time that the gravels, sands, and finer sediments of the Merced were being deposited in the ocean, somewhat similar sediments were being laid down in great fresh-water lakes on the opposite side of the Coast Range. These fresh-water deposits are now exposed in a narrow band which extends from the region of the Crystal Springs Lakes along the eastern side of a main ridge bordering the Santa Clara Valley on the west. Fresh-water fossils have been found within this formation at several points. Among these are the following:

*List of Fresh-water Pliocene-Pleistocene fossils from the Santa Cruz quadrangle.*

*Anodonta wahlametensis* Lea.
*Amnicola*, species, *a*.
*Amnicola*, species, *b*.
*Paludestrina*, species, *a*.
*Paludestrina*, species, *b*.

## QUATERNARY.

The Quaternary in the Santa Cruz quadrangle was a period of intermittent uplift and depression. The record of the changes that have taken place during it are found in the wave-cut and stream terraces and the marine and fresh-water deposits which occur in different parts of the quadrangle. With the exception of some mammal bones found in the stream gravels on the Santa Clara side of the main range, the most important fossiliferous deposits are on the raised terraces along the coast. Two localities have yielded a considerable fauna, these being the raised terraces at Año Nuevo Point and near the light-house at Santa Cruz. The following fossils have been found in the Pleistocene deposits above mentioned:

*List of Pleistocene fossils from the Santa Cruz Quadrangle.*

### PELECYPODA.

*Macoma nasuta* Conrad.
*Pecten* (*Hinnites*) *giganteus* Gray.
*Pholadidea penita* Conrad.
*Rupellaria lamellifera* Conrad.
*Saxidomus gracilis* Gould.
*Zirphæa gabbi* Tryon.

### GASTEROPODA.

*Amphissa corrugata* Reeve.
*Astyris gausapata* Gould.
*Bela fidicula* Gould.
*Bittium filosum* Gould.
*Bittium rugatum* Conrad.
*Calliostoma costatum* Martyn.
*Columbella*, species, *a*.
*Fusus luteopictus* Dall.
*Isapis*, species, *a*.
*Mangilia*, species, *a*.

*Margarita parcipicta* Carpenter.
*Margarita pupilla* Gould.
*Nassa mendica* Gould.
*Nassa perpinguis* Hinds.
*Natica clausa* Broderip and Sowerby.
*Ocinebra interfossa* Carpenter.
*Ocinebra lurida* Middendorf.
*Ocinebra lurida*, var. *aspera* Baird.
*Ocinebra lurida*, var. *cancellina* Philippi.
*Ocinebra lurida*, var. *munda* Carpenter.
*Ocinebra perita* Hinds.
*Odostomia nuciformis* Carpenter.
*Odostomia nuciformis*, var. *avellana* Carpenter.
*Phasianella compta* Gould.
*Spiroglyphus lituella* Morch.
*Thais canaliculatus* Duclos.

## DESCRIPTIONS OF NEW SPECIES.

The following are the new species described:

- Cretaceous species.
  - Pelecypoda.
    - *Mactra stantoni*, new species.
  - Gasteropoda.
    - *Turritella pescaderoensis*, new species.
- Eocene species.
  - Echinoidea.
    - *Cidaris merriami*, new species.
  - Pelecypoda.
    - *Semele gayi*, new species.
  - Gasteropoda.
    - *Tritonium newsomi*, new species.
    - *Hipponyx carpenteri*, new species.
    - *Patella mateansis*, new species.
    - *Fissurella perrini*, new species.
- San Lorenzo (Oligocene) species.
  - Echinoidea.
    - *Cidaris branneri*, new species.
  - Pelecypoda.
    - *Nucula* (*Acila*) *dalli*, new species.
    - *Malletia chehalisensis*, new species.
    - *Cardium cooperi* Gabb, var. *lorenzanum*, new variety.
    - *Tellina lorenzoensis*, new species.
  - Gasteropoda.
    - *Pleurotoma newsomi*, new species.
    - *Pleurotoma perissolaxoides*, new species.
    - *Pleurotoma sanctaecrucis*, new species.
    - *Strepsidura californica*, new species.
    - *Fusus hecoxi*, new species.
    - *Fusus sanctaecrucis*, new species.
    - *Lirofusus ashleyi*, new species.
    - *Turricula santacruzana*, new species.
    - *Architectonica lorenzoensis*, new species.
- Vaqueros (Lower Miocene) species.
  - Pelecypoda.
    - *Leda cahillensis*, new species.
    - *Yoldia submontereyensis*, new species.
    - *Glycymeris branneri*, new species.
    - *Cardium* (*Trachycardium*) *vaquerosensis*, new species.
  - Gasteropoda.
    - *Agasoma santacruzana*, new species.
- Monterey (Middle Miocene) species.
  - Pelecypoda.
    - *Venericardia montereyana*, new species.
    - *Mactra montereyana*, new species.
- Upper Miocene species.
  - Pelecypoda.
    - *Yoldia supramontereyensis*, new species.
    - *Periploma sanctaecrucis*, new species.
  - Gasteropoda.
    - *Fusus* (*Priscofusus?*) *stanfordensis*, new species.
    - *Agasoma stanfordensis*, new species.
- Purisima and Merced (Upper Miocene and Pliocene) species.
  - Gasteropoda.
    - *Fusus* (*Buccinofusus*) *portolaensis*, new species.
    - *Chrysodomus stantoni*, new species.
    - *Thais trancosana*, new species.
    - *Chlorostoma stantoni* Dall, var. *lahondaensis*, new variety.

## CRETACEOUS SPECIES.

## PELECYPODA.

### Genus MACTRA Linnæus.

### MACTRA STANTONI, new species.

Plate XXXI, fig. 3.

*Description.*—Shell averaging from 40 to 50 mm. in length, subtrigonal in outline, altitude about five-sevenths of length, equivalve, equilateral, the beaks located midway the shell, moderately thin, moderately convex. Anterior margin only very slightly depressed in front of beaks; quite evenly but somewhat acutely rounded in front; base evenly rounded; posterior margin sloping straight back from umbones; posterior extremity not quite as attenuate as anterior; a faint suggestion of an angle or carina extends from the beak to the posterior extremity. Surface sculptured by numerous small but sharply defined quite regular concentric ridges, separated by interspaces somewhat narrower than the latter, also by fine incremental lines which appear more prominent where the concentric ridges are obsolete. Hinge only moderately strong, umbonal pit small; lateral teeth high and thin, extending above the adjacent margins of the shell. Interior unknown.

*Dimensions.*—Length (restored), 50 mm.; latitude, 34 mm.; diameter (1 valve), 12 mm.; umbonal angle about 120°.

*Notes.*—This species is quite unlike any other found in the Cretaceous of the west coast. Distorted specimens, however, resemble *Tapes conradiana* Gabb, owing to the peculiar appearance of the concentric ribs. Numerous specimens of *M. stantoni* occur in the sandstone at locality No. 27, north of Pigeon Point, where most of the individuals are more or less distorted. The specimen figured is the best of those collected.

Named in honor of Dr. Timothy W. Stanton, chief paleontologist, United States Geological Survey.

*Type.*—Cat. No. 31001, U.S.N.M., 1 mile north of Pigeon Point, locality No. 27.

*Horizon.*—Chico formation, upper Cretaceous.

*Locality.*—Santa Cruz quadrangle, San Mateo County, locality No. 27. (Arnold.)

## GASTEROPODA.

### Genus TURRITELLA Lamarck

### TURRITELLA PESCADEROENSIS, new species.

Plate XXXI, fig. 7.

1895. *Turritella hoffmani* Ashley (not Gabb), Neocene Santa Cruz Mts., Proc. Calif. Acad. Sci., Ser. 2, V, 1895, p. 299.

*Description.*—Shell elongate, conical, large, often attaining a diameter of over 25 mm.; apex acute. Whorls at least 10, flat to convex above, convex below, excavated at base; there are 4 prominent, subequal, strong, squarish, often more or less nodose revolving ribs separated by concave-bottomed, channeled interspaces equal to or narrower than the ribs; the 2 lower ribs are usually slightly larger than the 2 upper; in addition to the 4 major ribs there are 2 sutural ribs, less prominent and more rounded than the others, one on each side of the suture and close to it, and sometimes an intercalated revolving raised line in one or more of the interspaces; fine incremental lines are visible in some specimens; base spirally striate; aperture subquadrate.

*Dimensions.*—Length (restored), about 110 mm.; latitude, 25 mm.; apical angle, 14°.

*Notes.*—A comparison of this robust species with some specimens of *T. chicoensis* Gabb from Pentz, Butte County, near the type-locality of the latter, reveals the following differences: *T. pescaderoensis* is larger, relatively broader (*T. chicoensis* has a deflection of 11° to 12°), has a much less pronounced basal excavation, has much stronger and more nearly equal and closer spaced revolving ribs, which are usually more rugose, and has more prominent sutural riblets. Specimens, which are believed to be a variety of *T. chicoensis*, from the Chico formation of the Santa Ana Mountains, Orange County, more closely resemble *T. pescaderoensis* than the typical form, being almost equal to the former in size and relative width, but showing the sculpture characteristics of the typical *T. chicoensis*. Named for the town of Pescadero, near which is the type-locality.

*Type.*—Imperfect specimen showing 3 large whorls, L. S. J. U., No. 999. (Locality No. 27 A.)

*Horizon.*—Chico formation, upper Cretaceous.

*Localities.*—Santa Cruz quadrangle, San Mateo County, locality No. 27 A, about 2¼ miles north of Bolsa Point, in transition sandstone and conglomerate layers between the thin-bedded sandstones below and the heavy-bedded coarse conglomerate above. (G. H. Ashley, J. M. Hyde, J. F. Newsom, R. Arnold.)

EOCENE SPECIES.

# ECHINOIDEA.

## Genus CIDARIS Leske.

### CIDARIS MERRIAMI, new species.

Plate XXXII, fig. 8.

*Description.*—Spines subcircular in cross-section, as much as 4 mm. in diameter and probably over 40 mm. in length, tapering very slightly; surface sculptured by 13 or 14 prominent, narrow, nodose, ridge-like, longitudinal ribs separated by narrow, deeply incised grooves; the nodes are well defined, especially in the younger stages of growth, and are subelliptical in cross-section, their longer axis being parallel with the axis of the spine. Test unknown.

*Dimensions.*—The longest fragment obtained was over 20 mm. in longitude, the maximum diameter 4.5 mm.

*Notes.*—The test of this species is unknown, but the abundance and well marked characteristics of the fragments of the spines has been deemed of enough importance to justify a specific name. Seven specimens have been obtained at the type locality, each showing the characters described above.

Named in honor of Dr. John Charles Merriam, professor of paleontology at the University of California.

Dr. Hubert Lyman Clark, who kindly examined the type and other specimens of *Cidaris merriami* new species, *Cidaris branneri*, new species, from the Oligocene (see p. 363), and *Cidaris* species, *a*, from the middle Miocene (see p. 351), writes as follows concerning the relationships of the various forms:

> The wax cast [*Cidaris* species, *a*] is a spine of a true *Cidaris* and very much like many spines of some individuals of the species of *Cidaris* common on the west coast of Lower California, Mexico, and Central America, *C. thouarsii*. I do not think it shows a single feature by which it can be distinguished from *thouarsii*. If it is not *thouarsii*, it is certainly from the ancestor of that species.
>
> The other specimens [*Cidaris merriami*, new species] all appear to belong to one species, except possibly one fragment. That piece might *possibly* have come from quite a different species. I am very glad to see this material of *merriami*, for it satisfies me that the species must have been allied to, if not identical with, *Tretocidaris perplexa* Clark (Cidaridæ, 1907, p. 205, pl. VI, figs. 1–2; pl. VII, figs. 1–4), the only other living littoral Cidarid known from north of Panama (other, I mean, than *thouarsii*). So your material shows that the ancestors of both *thouarsii* and *perplexa* lived in the Tertiary, in California. I think the other spine [*Cidaris branneri*, new species], * * * which I said was like *Goniocidaris*, is almost surely a third species.

*Type.*—Imperfect spine. Cat. No. 165438, U.S.N.M.

*Horizon.*—Martinez formation, lower Eocene.

*Localities.*—Santa Cruz quadrangle, San Mateo County, locality No. 25, ridge between headwaters of San Lorenzo River and Pescadero Creek. (H. S. Gay, R. Arnold.)

## PELECYPODA.

### Genus SEMELE Schumacher.

### SEMELE GAYI, new species.

Plate XXXII, fig. 5.

*Description.*—Shell averaging about 14 mm. in latitude, subquadrate in outline, quite a little longer than wide, moderately inflated, rather thin, inequilateral, subequivalve. Beaks not prominent, turned slightly forward, situated about three-fifths length of shell from anterior end. Posterior margin slightly curved, sloping off rapidly toward anterior extremity, which is subangular and situated about one-third height of shell from the base; posterior fold very faint; anterior dorsal margin slightly depressed; anterior extremity more evenly and less sharply rounded than posterior; base evenly arcuate. Surface sculptured by numerous regular, fine, sharp concentric ridges, each with abrupt side toward the beak, the opposite side sloping, and each appearing to overlap its predecessor; in the larger specimens one or more well defined concentric grooves are sometimes found near the periphery. Interior showing well defined mantel impression parallel with margin and about one-sixth height of shell away from it; interior also coarsely radially grooved.

*Dimensions.*—Of imperfect right valve (type), restored; length, 17 mm.; latitude, 14 mm.; diameter of single valve, 2.8 mm.

*Notes.*—This species is apparently nearest related to *S. rubropicta* Dall (recent range, Washington to Mexico) of any of the living forms. It may be distinguished from the latter by its smaller size, finer and more regular concentric ribs, and lack of any external radiating sculpture. With the exception of *S. rubropicta*, *S. gayi* is more abruptly truncated posteriorly than any other member of the genus on the west coast.

Named in honor of Mr. Harold S. Gay, who first discovered the locality from which this species and its interesting associated fauna come.

*Type.*—Imperfect right valve, Cat. No. 165435, U.S.N.M.

*Locality.*—Santa Cruz quadrangle, San Mateo County, locality No. 25, between headwaters of San Lorenzo River and Pescadero Creek. (H. S. Gay, R. Arnold.)

## GASTEROPODA.

### Genus TRITONIUM Link.

### TRITONIUM NEWSOMI, new species.

Plate XXXII, fig. 6.

*Description.*—Shell averaging about 18 mm. in altitude, subquadrate in outline; spire elevated, apex acute; whorls 5 or more, the the two upper minute; the others rounded and sculptured by 4 revolving and about 14 narrow, ridge-like axial costæ, the intersections of the two systems producing a slightly nodose-cancellate appearance; varices 2 to a volution, prominent, rounded, not reflexed; suture appressed, slightly wavy.

*Dimensions.*—Of imperfect specimen, length, 17 mm.; latitude, 13 mm.; length of body whorl, 10 mm.; apical angle, 76°.

*Notes.*—Owing to the poor state of preservation of the type of this species, which happens to be the only one so far found, it is impossible to diagnose the characteristics of the aperture, lips, and details of sculpture. It belongs to the same general group as *T. californicum* Gabb[a] from the Tejon formation, upper Eocene, but is relatively much wider and has much stronger but less numerous revolving and axial costæ than the latter. The varices appear to be continuous on adjacent whorls in *T. newsomi* rather than more or less irregularly disposed, as in *T. californicum*.

Named in honor of Dr. John Flesher Newsom, professor of mining and metallurgy in Stanford University.

*Type.*—An imperfect specimen, lacking apex and canal. Cat. No. 165436, U.S.N.M.

*Horizon.*—Martinez (?) formation, lower Eocene.

*Locality.*—Santa Cruz quadrangle, San Mateo County, locality No. 25, ridge between headwaters of San Lorenzo River and Pescadero Creek. (R. Arnold.)

## Genus HIPPONYX De France.

### HIPPONYX CARPENTERI, new species.

Plate XXXII, figs. 3, 3a.

*Description.*—Shell averaging only 11 mm. in longitude, tumid, with elongate oval base; apex distinct, small, curved slightly to right, situated almost directly above posterior extremity of base; profile from apex to anterior extremity of base is slightly but regularly bowed upward; profile from apex to posterior extremity of base is straight or bowed slightly inward. Surface sculptured by numerous regular, rounded, radiating ridges separated by narrow incised interspaces and by less prominent, wider, less regular, imbricating concentric lamellæ; the radiating ridges are divaricate along a median line from anterior to posterior extremities; in some instances the incremental sculpture simply gives the radiating ridges a granulose appearance. Interior unknown.

*Dimensions.*—Length, 11 mm.; latitude (restored), 9 mm.; altitude, 4 mm.

*Notes.*—This beautiful little shell is quite closely allied to the living *Hipponyx tumens* Carpenter, but may be distinguished from the latter by its relatively narrower base, less prominent apex, and by its radiating ribs, which are equal instead of alternating large and small.

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[a] Pal. Cal., II, p. 154, pl. XXVI, fig. 33.

Named in honor of the late Dr. P. P. Carpenter, widely known in relation to his work on West American conchology, who named two west coast species of this genus.

*Type.*—Slightly imperfect specimen, Cat. No. 165433, U.S.N.M.

*Horizon.*—Martinez (?) formation, lower Eocene.

*Localities.*—Santa Cruz quadrangle, San Mateo County, locality No. 25, ridge between headwaters of San Lorenzo River and Pescadero Creek. (H. S. Gay, R. Arnold.)

## Genus PATELLA Linnæus.

### PATELLA MATEOENSIS, new species.

Plate XXXII, fig. 7.

*Description.*—Shell averaging about 7.5 mm. in longitude, conical, with subelliptical base, very slightly narrowed in front; beak acute, slightly anterior; profile from beak to both extremities slightly convex upward; margin wavy to serrate. Surface sculptured by numerous fine, more or less irregular lines of growth and about 22 narrow, ridge-like radiating ribs separated by wide flat-bottomed interspaces in which are often intercalated one or more minor riblets.

*Dimensions.*—Length, 7.5 mm.; latitude, 5.4 mm.; altitude, 2 mm.

*Notes.*—This species is similar in general outline to *Patella*, new species, *b*, but a series of over twenty specimens of the two show no intermediate forms. *P. mateoensis* is distinguished from *Patella*, new species, *b*, by its fewer, narrower ribs, which are simple instead of dichotomous, and between which are wider interspaces each usually containing one or two minor riblets. Named for San Mateo County, in which the type locality is situated.

*Type.*—Cat. No. 165437, U.S.N.M.

*Horizon.*—Martinez (?) formation, lower Eocene.

*Localities.*—Santa Cruz quadrangle, San Mateo County, locality No. 25, ridge between San Lorenzo River and Pescadero Creek. (H. S. Gay, R. Arnold.)

## Genus FISSURELLA Bruguiere.

### FISSURELLA PERRINI, new species.

Plate XXXII, fig. 4.

*Description.*—Shell averaging about 16 mm. in longitude, conical, flaring slightly toward bottom; base oblong, narrowed in front; margin notched; apical hole oblong, with plane of margin tilted slightly forward, situated a little more than one-third the length of the shell from the anterior extremity. Surface sculptured by numerous (38 in type) quite regular, rounded, slightly elevated radiating ribs, separated by flat-bottomed interspaces usually slightly wider than the ribs, and also by numerous sharp, imbricating, wavy, incremental lamellæ, which are most prominent on the tops of the ribs. Interior and details of apical hole unknown.

*Dimensions*—Length, 16 mm.; latitude, 10.2 mm.; altitude, 2.6 mm.

*Notes.*—No intercalated riblets were noted on any of the specimens examined. This species appears to be closest to *F. volcano* Reeve of the recent fauna, but differs from it in being smaller, relatively more depressed, and having the apical hole less central and the ribs fewer, farther apart, and more regular and more regularly disposed over the surface.

Named in honor of Dr. James Perrin Smith, professor of paleontology, Stanford University.

*Type.*—Nearly perfect specimen, Cat. No. 165434, U.S.N.M.

*Horizon.*—Martinez (?) formation, lower Eocene.

*Locality.*—Santa Cruz quadrangle, San Mateo County, on ridge between headwaters of San Lorenzo River and Pescadero Creek. (H. S. Gay, R. Arnold.)

## SAN LORENZO (OLIGOCENE) SPECIES.

## ECHINOIDEA.

### Genus CIDARIS Leske.

### CIDARIS BRANNERI, new species.

Plate XXXIII, fig. 5.

*Description.*—Test unknown. Spines, long, slender, circular in cross-section, attaining a length of at least 25 mm. and a diameter of over 2 mm. Surface of spine smooth for about one-fifth its length from the base; above this it is ornamented by 10 longitudinal rows of elongated nodes or granules which are barely connected near the smooth portion, but which partake more and more of the character of nodose ribs toward the distal end; the last one-fifth of the spine is ornamented by 5 prominent, slightly nodose ribs; the extreme end is blunt and rounded; collar at base only faintly developed.

*Dimensions.*—Length, 20 mm.; diameter, basal end, 2.2 mm.; distal end, 1.1 mm.

The spines of this species are easily distinguishable from those of *C. merriami*, new species, from the Eocene, by their smaller size, fewer but much more prominently nodose longitudinal ribs, and smooth basal portion. No complete spine of *C. merriami* was obtained, so that the smooth basal section may possibly be a characteristic of this latter species as well as of *C. branneri*. (See note under description of *C. merriami*, p. 359, for a discussion of the zoologic relations of this species.)

Named in honor of Dr. John Casper Branner, professor of geology, Stanford University.

*Type.*—External mold of almost perfect spine, L.S.J.U., No. 1056. (Locality, No. 109.)

*Horizon.*—San Lorenzo formation, Oligocene, upper portion transitional toward Vaqueros formation, lower Miocene.

*Locality.*—Santa Cruz quadrangle, Santa Cruz County, locality No. 109, on Bear Creek, 4 miles above its confluence with the San Lorenzo River. (J. F. Newsom.)

## PELECYPODA.

### Genus NUCULA Lamarck.

### Subgenus ACILA H. and A. Adams.

### NUCULA (ACILA) DALLI, new species.

Plate XXXIII, fig. 15.

*Description.*—Shell trigonal in outline, nearly as broad as long, large for a member of this genus, sometimes attaining a length of over 30 mm., rather compressed, strongly divaricately sculptured. Umbones prominent and turned backward, placed very near the posterior end, which is abruptly truncated and depressed, and forms a straight or slightly inwardly curved line from the umbones to the base, with which it makes a sharp angle of about 90°; base rounded, becoming more and more so toward the anterior extremity, which region exhibits the sharpest curvature of any on the anterior portion of the shell; anterior dorsal margin nearly straight for a considerable distance in front of the umbones; a faint carina extends from the umbo to the posterior ventral angle; surface sculptured by numerous rounded, raised, divaricating lines; margins crenulate. Hinge as in other members of this genus.

*Dimensions.*—Length, 33 mm.; latitude, 28 mm.; diameter of both valves together about 14 mm.

*Notes.*—This magnificent species is easily distinguishable from the other west coast forms by its great size, great breadth, and coarse, well defined sculpture. In size it approaches the gigantic *Acila mirabilis* Adams and Reeve, from the recent fauna of Japan.

Named in honor of Dr. William Healey Dall, of the United States Geological Survey.

*Type.*—Mold of exterior of left valve, Cat. No. 165452, U.S.N.M. (Locality No. 115.)

*Horizon.*—San Lorenzo formation, Oligocene, and possibly also the Monterey shale, middle Miocene.

*Localities.*—Santa Cruz quadrangle, Santa Cruz County, locality Nos. 100, 101, and 102, on San Lorenzo River, 3, $3\frac{1}{2}$, and $5\frac{1}{4}$ miles, respectively, above the town of Boulder Creek; locality No. 103, Kings Creek, three-eighths mile above its confluence with San Lorenzo River; locality No. 104, Boulder Creek, $5\frac{1}{4}$ miles above its confluence with San Lorenzo River; locality No. 107, in small ravine off Boulder Creek, 2¼ miles north of Eagle Rock; localities Nos. 115, 116 and 117, the first two on the headwaters of the South Fork, the last on the headwaters of the North Fork, of Waddell Creek, in the Big Basin. (R. Arnold, W. R. Hamilton, H. L. Hamilton, etc.)

## Genus MALLETIA Desmoulins.

### MALLETIA CHEHALISENSIS, new species.

Plate XXXIII, figs. 9, 9a.

*Description.*—Shell attaining a length of 25 mm., oval, compressed, smooth; umbones rather inconspicuous, slightly anterior to middle, turned backward; anterior dorsal margin sloping straight from umbo; anterior extremity regularly rounded; posterior dorsal margin straight, depressed immediately in rear of umbones; posterior extremity above medial line, more attenuated than the anterior; posterior portion of base near extremity nearly straight, otherwise quite regularly curved. Surface smooth, except for faint concentric lines. Hinge consists of a row of sharp teeth flexed toward the umbo on each side of a prominent, projecting umbonal pit. Pallial sinus large and deep.

*Dimensions.*—Length, 7.4 mm.; latitude, 4.5 mm.; diameter of single valve, 1.5 mm.

*Notes.*—This species is very closely allied to *M. gibbsii* Dall, dredged at U. S. Bureau of Fisheries Station 2860 in 876 fathoms off Queen Charlotte Island, but may be distinguished from the latter by its prominent umbonal pit and straighter posterior dorsal margin. The type is a rather undersized specimen, chosen for its perfect state of preservation, the species usually attaining a larger size. The specimens from the Santa Cruz quadrangle reach a length of over 12 mm.

Named for Chehalis County, Washington, where the type was found.

*Type.*—Cat. No. 165447, U.S.N.M., Porter, Chehalis County, Washington.

*Horizon.*—San Lorenzo formation, Oligocene (Santa Cruz region; Oligocene (Porter, Washington); base of Oligocene-Miocene (Washington).

*Localities.*—Santa Cruz quadrangle, Santa Cruz County, locality No. 103, Kings Creek, three-eighths mile above its confluence with San Lorenzo River; locality No. 104, on Boulder Creek, 5 miles northwest of its confluence with the San Lorenzo River; locality No. 106, on Twobar Creek, 1 mile above its confluence with the San Lorenzo River; locality No. 107, small ravine off Boulder Creek, 2¼ miles north of Eagle Rock (R. Arnold); also in basal portion of Oligocene-

Miocene series west of Gettysburg and west of Port Crescent, Clallam County, and in Kitsap County, opposite Seattle, Washington (R. Arnold); Oligocene, Porter, Washington (R. Arnold).

## Genus CARDIUM (Linnæus) Lamarck.

### CARDIUM COOPERI Gabb, var. LORENZANUM, new variety.

Plate XXXIII, fig. 6.

*Description.*—Shell attaining a length of only about 14 mm.; somewhat longer than high; end view of both valves together has a cordate appearance; outline of a single valve subcircular; shell very convex, thin; umbo small, prominent, turned slightly forward, projecting beyond dorsal margin; dorsal margin straight for short distance under umbo, bends off slightly more angularly posteriorly than it does anteriorly; extremities broad and regularly rounded, as is also the base; surface sculptured by fine incremental lines and by numerous fine radiating lines, those over the posterior end being larger and more prominent than those on the remainder of the shell, and distinctly separated from the latter by a faint angle in the surface of the shell extending from umbo to posterior ventral margin. Margin minutely crenulate. Lunule faint or lacking.

*Dimensions.*—Length, 14 mm.; altitude, 12.5 mm.; diameter of single valve, 4.5 mm.

*Notes.*—Gabb, in the original description[a] of *C. cooperi*, writes that no carina or angle separates the two differently sculptured portions of the shell. Specimens of *C. cooperi* from the Eocene of Rose Canyon, north of San Diego, show a faint angle at this point. *C. cooperi* Gabb, var. *lorenzanum*, new variety, apparently differs from the typical Eocene form in size only, the latter often attaining a length of nearly 40 mm., although in the type of the new variety the lunule is lacking. Other specimens from the same horizon as the latter show a faint lunule. The small variety is apparently confined to the Oligocene, while the typical form is characteristic of the Eocene.

*Type.*—Slightly imperfect right valve, Cat. No. 165444, U.S.N.M. (Locality No. 4063, Porter, Washington.)

*Horizon.*—San Lorenzo formation, Oligocene.

*Localities.*—Santa Cruz quadrangle, Santa Cruz County, locality No. 101, on San Lorenzo River, 3⅜ miles north of Boulder Creek; locality No. 103, on Kings Creek, one-half mile above confluence with San Lorenzo River; locality No. 106, on Twobar Creek, seven-eighths mile above its confluence with San Lorenzo River; locality No. 107, on small ravine off Boulder Creek, 2¼ miles north of Eagle Rock; locality No. 108, beside road on ridge between headwaters of South Fork of Waddell Creek, and Boulder Creek, 1 mile north of Eagle

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[a] Pal. Cal., 1, p. 172.

Rock; locality No. 117, on east branch of North Fork of Waddell Creek, Big Basin (R. Arnold). Also at U. S. Geological Survey locality Nos. 4063 and 4064, Porter, Chehalis County, and locality No. 4071, Restoration Point, Kitsap County, opposite Seattle, Washington (R. Arnold).

### Genus TELLINA Linnæus.

#### TELLINA LORENZOENSIS, new species.

Plate XXXIII, fig. 1.

*Description.*—Shell attaining a length of 40 mm., width a little over five-eighths of length, oblong, compressed, slightly inequivalve, anterior end evenly rounded, posterior end biangular and narrower than anterior; umbo small, central, though sometimes, as in type, placed a little in front of middle; sides making an angle of 125° at the umbo; anterior dorsal margin very gently curved near umbo, becoming rapidly more curved near extremities; ventral dorsal margin very gently curved for whole length to upper posterior angle; a moderately sharp fold, on which the lines of growth are particularly prominent, extends from the umbo to the lower posterior angle; a faint indication of a reentrant angle often occurs in the margin at the end of the fold; base nearly straight, curving quite rapidly at ends. Surface sculptured by numerous slightly unequal concentric lines. Left valve similar to right except that instead of being very slightly flexed upward at the posterior extremity, it is flexed downward.

*Dimensions.*—Length, 40 mm.; latitude, 26 mm.; diameter single valve, 3 mm.

*Notes.*—This species is very closely allied to *T. rubescens* Hanley from the recent fauna of the west Mexican coast, but may be distinguished by its more anterior umbo, slightly sharper posterior fold, less sharply angular and usually less flexed posterior extremity, and considerably finer concentric sculpture. *T. lorenzoensis* also resembles *T. eburnea* Hanley of the Panama fauna, but is smaller and has finer sculpture and other minor differences. It is unlike any of the other west coast Oligocene and Miocene forms in having a more central umbo. Named for the San Lorenzo formation, of which it is believed to be characteristic.

*Type.*—Mold of right valve, from which specimen figured is the cast; Cat. No. 165439, U.S.N.M. (Locality No. 115.)

*Horizon.*—San Lorenzo formation. Oligocene.

*Localities.*—Santa Cruz quadrangle, Santa Cruz County, locality No. 107, on small ravine off Boulder Creek, 2¼ miles north of Eagle Rock (R. Arnold; I. Anderson); locality No. 115, on southeast branch of South Fork of Waddell Creek, Big Basin (R. Arnold, W. R. Hamilton).

## GASTEROPODA.

### Genus PLEUROTOMA Lamarck.

**PLEUROTOMA NEWSOMI**, new species.

Plate XXXIII, fig. 2.

*Description.*—Shell about 12 mm. in length, spindle-shaped and exceedingly slender; spire very long and apex acute. Whorls 6, convex, sharply angulated, the angle carrying a very prominent, rounded revolving rib; upper and lower surfaces of whorl concave and bordered by moderately pronounced sutural ridges; body whorl biangular, each angle carrying a revolving ridge similar to those on upper whorls, the lower ridge being slightly less prominent than the upper; below the lower rib is still a third much smaller one; between and below the revolving ridges on the body whorl are several minor raised revolving lines (3 between the major revolving lines on the type); faint indications of spiral lines are also visible on the concave surfaces of the upper whorls. Suture distinct. Aperture subovate. Canal long, narrow, nearly straight.

*Dimensions.*—Length, 12 mm.; latitude, 3.3 mm.; apical angle, 18°.

*Notes.*—This species is entirely unlike any previously described *Pleurotoma* from the west coast and is characterized by its exceeding slenderness and the prominence of the revolving cord-like ridges. The character of the spiral sculpture, especially of the body whorl, reminds one somewhat of *Perissolax blakei* Conrad from the Tejon (Eocene). Named in honor of Dr. John Flesher Newsom, of Stanford University.

*Type.*—Cat. No. 165140, U.S.N.M. (Locality No. 107.)

*Horizon.*—San Lorenzo formation, Oligocene.

*Locality.*—Santa Cruz quadrangle, Santa Cruz County, locality No. 107, in small ravine off Boulder Creek, 2¼ miles north of Eagle Rock. (R. Arnold, Isaac Anderson.)

**PLEUROTOMA PERISSOLAXOIDES**, new species.

Plate XXXIII, fig. 13.

*Description.*—Shell about 28 mm. in length, fusiform; spire well elevated; apex moderately acute; whorls at least 5, very angular with an exceedingly prominent revolving smooth keel on angle which is near base of whorl; upper portion of whorl flat or slightly concave; surface ornamented by microscopic revolving striæ and numerous fine incremental lines which indicate a very deep narrow sulcus in the outer lip just above the keel of the whorl; body whorl carrying a second keel less prominent than and below the major keel and distant from it about one-sixth the length of the body whorl; suture distinct, appressed, and just overlapping the lower keel of the antecedent whorl; aperture subpyriform; canal moderately long, tapering quite rapidly forward.

*Dimensions.*—Of type, from which a portion of the spire is removed, length, 24 mm.; latitude, 13 mm.

*Notes.*—The type of this species is a fairly well preserved mold of the penultimate and body whorls (locality No. 107); the figure is of a wax cast from the mold; another specimen of the same species from locality No. 101 retains a portion of the original shell material and furnishes the detailed characters of the external sculpture. *P. perissolaxoides* reminds one of the young of the living *P. circinata* Dall from Alaska, but differs from the latter in having a minor keel on the body whorl. Named for its general resemblance to *Perissolax blakei* Conrad from the Eocene of California.

*Type.*—Cat. No. 165451, U.S.N.M. (Locality No. 107.)

*Horizon.*—San Lorenzo formation, Oligocene.

*Localities.*—Santa Cruz quadrangle, Santa Cruz County, locality No. 101, on San Lorenzo River about 3¾ miles above Boulder Creek; locality 107, small ravine off Boulder Creek about 2¼ miles north of Eagle Rock. (R. Arnold.)

### PLEUROTOMA SANCTÆCRUCIS, new species.

Plate XXXIII, fig. 7.

*Description.*—Shell about 18 or 20 mm. in length, broadly fusiform in shape; spire elevated cone-shaped, straight-sided; apex moderately acute; whorls 6 or more, biangular, tabulated above and below, near suture, which is canal-like and very deeply and prominently impressed; upper surface of whorl concave, side flat and sloping exactly with slope of spire, base flat and its plane practically perpendicular to the axis of the shell, surface sculptured by minute incremental lines and 1 or 2 obsolete revolving lines. Canal and aperture unknown; sinus as indicated by incremental lines corresponded in position to the upper angle of the whorl.

*Dimensions.*—Of spire from which canal is lacking, length, 8 mm.; latitude, 7 mm.

*Notes.*—This peculiar species of which only the type is known is easily distinguished by its deep canal-like suture and the shape of the whorl the side of which is sloping with the slope of the sides of the spire, while the top and bottom are in planes practically perpendicular to the axis of the whole spire. Named for the Santa Cruz quadrangle.

*Type.*—Cat. No. 165445, U.S.N.M. (Locality No. 108.)

*Horizon.*—San Lorenzo formation, Oligocene.

*Locality.*—Santa Cruz quadrangle. Santa Cruz County, locality No. 108, on road between headwaters of Boulder Creek and South Fork of Waddell Creek, about a mile north of Eagle Rock. (R. Arnold.)

## Genus STREPSIDURA Swainson.

### STREPSIDURA CALIFORNICA, new species.

Plate XXXIII, fig. 12.

*Description.*—Adult shell attaining an altitude of at least 40 mm., broadly fusiform; spire elevated; apex acute. Whorls 5 or 6, upper whorls prominently angular, body whorl biangular with a very faint suggestion of a third angle below the other two; posterior margin of each whorl appressed against the middle of the antecedent whorl, covering the lower angle of the latter; upper portion of whorl flat or concave, middle of whorl between angles, exceedingly concave; angles ornamented by several (13 on body whorl of type) prominent sharp nodes which protrude straight out from the angle, flexing neither backward nor forward, and merge into faint or obsolete axial ribs on the body of the whorl; posterior portion of whorl showing a faint sutural carina; three uppermost whorls less prominently nodose but rather more cancellate than the lower ones; surface sculptured by numerous, sometimes alternating, sometimes subequal, raised revolving lines; these lines are usually much finer and closer set on the angles than on the body of the whorl; fine incremental lines are also plainly seen over much of the surface, especially the lower portion of the body whorl, and sometimes irregular lines of interrupted growth cross the whorls approximately parallel with the axis of the spire. Suture deeply appressed, slightly wavy. Pillar short, basal portion turned outwardly with a biangular fold at the base of the aperture. Aperture subpyriform.

*Dimensions.*—Altitude, 32 mm.; latitude, 23 mm.; altitude of body whorl, 22 mm.

*Notes.*—*S. californica* is allied to *S. oregonensis* Dall[a] from the Eocene of Oregon, but is distinguished from the latter by its somewhat sharper spire, much more strongly angulated and nodose whorls, coarser revolving lines, and less well-defined third angle on the lower part of the body whorl.

*Type.*—Cat. No. 165450, U.S.N.M.

*Horizon.*—San Lorenzo formation, Oligocene.

*Localities.*—Santa Cruz quadrangle, Santa Cruz County, locality No. 103, near mouth of Kings Creek; locality No. 108, on road near divide between headwaters of South Fork of Waddell Creek and

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[a] Professional Paper No. 59, U. S. Geological Survey, pl. II, fig. 6.

Boulder Creek, and locality No. 117, on the East Fork of the North Fork of Waddell Creek, in the Big Basin (R. Arnold); also found in the Oligocene at Porter, Washington (U. S. Geological Survey, locality No. 4063).

## Genus FUSUS Lamarck.

### FUSUS HECOXI, new species.

Plate XXXIII, fig. 8.

*Description.*—Shell about 50 mm. in length, slender, fusiform; apex acute. Whorls 6 or 7, moderately angulated, concave above angle, slightly convex below; an almost obsolete narrow revolving band marks the upper margin of the whorl; 10 regularly rounded slightly oblique nodes surmount the angle and become obsolete a short distance both above and below it; the obliquity of the nodes is in a direction sloping downward toward the left; whole surface sculptured by alternating major and minor narrow, raised, revolving lines and occasionally by obsolete microscopic revolving striæ; suture appressed, distinct.

*Dimensions.*—Of imperfect type, length, 36 mm.; latitude, 18 mm.; apical angle, 40°.

*Notes.*—A large specimen believed to be of this species from locality No. 105, on Love Creek, shows 2 instead of 1 minor lines between some of the major revolving ones; this large specimen measures 25 mm. in width. *F. hecoxi* is closely related to *F. sanctæcrusis*, but may be distinguished from the latter by its greater size, relatively broader spire, nodose rather than axially ribbed whorls, and by the alternating character of its spiral lines. Like *F. sanctæcrusis*, *F. hecoxi* is allied to *F. geniculus* Conrad from the Oligocene of Oregon, but may be distinguished from the last by the greater angularity of its whorls, by the concave outline of the upper portion of the whorl, by its nodose rather than axially ridged sculpture, and by the coarser character of its revolving lines. *F. hecoxi* also resembles *Priscofusus medialis* Conrad from Astoria, but is slenderer, has larger, broader nodes and much more prominent spiral sculpture.

Named in honor of Miss Laura J. F. Hecox, United States lighthouse keeper, Santa Cruz, whose collection of specimens and interest in natural history has been an inspiration to all who have had the pleasure of her acquaintance.

*Type.*—Cat. No. 165446, U.S.N.M. (Locality No. 100.)

*Horizon.*—Near base of San Lorenzo shale, Oligocene.

*Localities.*—Santa Cruz quadrangle, Santa Cruz County, locality No. 100, 3 miles above the town of Boulder Creek on the San Lorenzo River; locality No. 103, near mouth of Kings Creek; locality No. 104, 5½ miles above the town of Boulder Creek on Boulder Creek; locality No. 105, on Love Creek, 2 miles above its confluence with the San Lorenzo River. (Ralph Arnold.)

### FUSUS SANCTÆCRUCIS, new species.

Plate XXXIII, fig. 3.

*Description.*—Shell about 45 mm. in length, slender, fusiform; apex acute. Whorls 6 or 7, convex below, flat to concave above; about 12 slightly oblique (sloping downward toward the left), narrow, wave-like ridges extend across each whorl from a short distance below the upper margin to the lower margin, becoming best developed on the angle of the whorl; a flat, narrow, roughened band forms the upper margin of the whorl; surface sculptured by numerous fine, equal, equidistant, raised spiral lines, most prominent between the longitudinal ridges; suture distinct, slightly wavy. Canal long, narrow, bowed slightly outward.

*Dimensions.*—Length (restored), 44 mm.; latitude, 12 mm.; length of body whorl, 30 mm.

*Notes.*—This species is characterized by its slender form, long slender canal, and the equality of its revolving lines. It resembles *F. geniculus* Conrad from the Oligocene of Astoria, Oregon, but is easily distinguished from the latter by its slenderer form and the regularity of its spiral sculpture. *F. sanctæcrucis* is distinguishable from *F. hecoxi* by its slenderer form, narrower and relatively longer axial varices, and equality of the spiral lines; it comes from a considerably higher part of the formation than the latter. The plastotype, which is figured, shows the spiral sculpture over only a portion of the shell. Named for the Santa Cruz quadrangle.

*Type.*—L. S. J. U., No. 1037. (Locality No. 109.)

*Horizon.*—San Lorenzo formation, Oligocene, upper portion transitional into Miocene.

*Locality.*—Santa Cruz quadrangle, Santa Cruz County, locality No. 109, Bear Creek, 4 miles above its confluence with San Lorenzo River. (J. F. Newsom.)

## Genus LIROFUSUS Conrad.

### LIROFUSUS ASHLEYI, new species.

Plate XXXIII, fig. 11.

*Description.*—Shell about 23 mm. in altitude, broadly fusiform; spire elevated, apex moderately acute. Whorls about 6+, ventricose; upper whorls biangular; body whorl triangular; a prominent nodose to undulating, squarish, narrow revolving ridge ornaments the lower angle, while a much less prominent ridge surmounts the upper; on the body whorl a third revolving ridge equal in prominence to the major ridge marks the third angle, and below this are 8 or 9 minor revolving ridges, which become less and less prominent toward the anterior end of the shell; a faint carina revolves just below the suture; whole surface marked by fine incremental lines and numerous, microscopic revolving striæ; on the last and penultimate whorls, are faint longitudinal undulations which rise to the prominence of faint nodes on the revolving ridges; suture appressed, distinct; canal quite short and rather narrow, curved slightly outward; aperture pyriform.

*Dimensions.*—Of type, from which canal is broken, length, 12 mm.; latitude, 12 mm.

*Notes.*—This species is quite unlike any other *Fusus* from the west coast, but is aparently allied to *Lirofusus thoracius* Conrad from the Claiborne Eocene. It is less tabulated than the latter, however, and has a much shorter canal and less prominent axial sculpture.

Named in honor of Dr. George Hall Ashley, of the United States Geological Survey, one of the pioneer paleontologists to investigate the Santa Cruz region.

*Type.*—Cat. No. 165449, U.S.N.M. (Locality No. 100.)

*Horizon.*—San Lorenzo formation, Oligocene.

*Localities.*—Santa Cruz quadrangle, Santa Cruz County, locality No. 100, San Lorenzo River, 3 miles above the town of Boulder Creek; locality No. 107, small ravine 2¼ miles north of Eagle Rock; locality No. 108, on road on divide between headwaters of South Fork of Waddell and Boulder creeks; locality No. 110, Two Bar Creek, 1½ miles up from mouth; locality No. 115, South Fork of Waddell Creek, 1¼ miles southwest of Eagle Rock; locality No. 117, North Fork of Waddell Creek, 3¾ miles west-northwest of Eagle Rock. (R. Arnold, W. R. Hamilton, and others.)

## Genus TURCICULA Dall.

### TURCICULA SANTACRUZANA, new species.

Plate XXXIII, fig. 4.

*Description.*—Shell turbinated, solid, averaging about 35 mm. in altitude; spire considerably elevated; apex only moderately acute; suture deeply impressed, distinct; whorls 5, quite convex, biangular, upper angle about middle of whorl, lower one-half way between upper one and base; surface above upper angle gently sloping, flat to slightly concave; surface between angles and between lower angle and suture decidedly concave; the upper angle is ornamented by about 18 low but distinct rounded nodes, while the lower angle and a slightly raised sutural ridge at the upper margin of the whorl each carry twice as many but slightly less prominent nodes; a faint obliquely sloping ridge parallel with the incremental sculpture often connects the alternate nodes on the sutural ridge with the nodes on the upper angle; between the lower angle and the umbilical region on the body whorl are 6 or 7 revolving ridges, the first and the most prominent, slightly tuberculated, the others diminishing in importance and nodosity and in distance apart as the umbilical region is approached; the surface of all the whorls is crossed by numerous fine incremental lines which slope downward and backward from the upper margin, at an angle deflecting about 25° from the vertical; aperture subcircular; lip simple; character of shell material, nacreous, over which in the well-preserved fragments is a horny epidermis in which the nodes of the underlying layer are somewhat exaggerated.

*Dimensions.*—Of type (restored), altitude, 35 mm.; latitude, 35 mm.; apical angle between 85° and 90°.

*Notes.*—This magnificent species is apparently the precursor of *T. bairdii* Dall, now found living off the California coast; it differs from the latter in its more angular whorl and more tabulate upper portion of the whorl, in its less conspicuous nodes on the sutural carina, in its stronger revolving basal ridges, and in minor points in the secondary sculpture. *T. santacruzana* is much smaller and relatively shorter than *T. columbiana* Dall from the Eocene of Rock Creek, Columbia County, Oregon, and has an entirely different arrangement of the nodes and revolving ridges than the latter.

Named for the Santa Cruz quadrangle, in which it has so far only been found.

*Type.*—Slightly decolleté specimen, Cat. No. 165,442; U.S.N.M. (Locality No. 100.)

*Horizon.*—San Lorenzo formation, Oligocene.

*Localities.*—Santa Cruz quadrangle, Santa Cruz County, locality No. 100, on San Lorenzo River, 3 miles above the town of Boulder Creek, abundant; locality No. 102, San Lorenzo River, 5¼ miles north of Boulder Creek. (R. Arnold, R. Anderson.)

## Genus ARCHITECTONICA Bolten.

### ARCHITECTONICA LORENZOENSIS, new species.

Plate XXXIII, fig. 10.

*Description.*—Shell spiral, conical, depressed, attaining a diameter of 20 mm.; spire low, whorls 5 or 6, quite evenly but moderately convex; suture deeply impressed. Upper whorls ornamented by 3 raised spiral lines; body whorl biangular, the two angles being close together and each bearing a rounded revolving rib; upper surface of body whorl bearing an impressed groove near the suture and between this and the periphery 2 quite prominent raised lines and 1 or more subsidiary revolving striæ; base very slightly convex, carrying a crenulated revolving rib adjacent to umbilicus, 1 or 2 incised grooves outside of this and finally 2 or 3 revolving raised lines toward the periphery; whole surface of whorls ornamented by numerous sharp, subequal, incremental lines which slope obliquely downward and backward from the upper margin. Umbilicus wide, spiral, and margins crenulated by rib previously mentioned; aperture subquadrate; lip simple.

*Dimensions.*—Of type, imperfect specimen, approximate, altitude, 8 mm.; latitude, 19 mm.

*Notes.*—This beautiful species, of which a rather imperfect mold is the type, has so far been found only at locality No. 107. All of the specimens figured are wax casts from molds in the soft sandstone matrix. *A. lorenzoensis* is allied to *A. hornii* Gabb from the Tejon (Eocene), from which it differs by its larger size and spirally sculptured upper surfaces of the whorls, and also to *A. blanda* Dall from the Eocene of Fall Creek, Oregon, from which it differs by having raised spiral lines near the periphery, rather than an entire spiral sculpture of impressed grooves.

Named for the San Lorenzo formation, of which it is believed to be characteristic.

*Type.*—Imperfect mold, Cat. No. 165448, U.S.N.M.

*Horizon.*—San Lorenzo formation, Oligocene.

*Locality.*—Santa Cruz quadrangle. Santa Cruz County, locality No. 107, on small ravine off Boulder Creek, 2¼ miles north of Eagle Rock. (R. Arnold, I. Anderson.)

## VAQUEROS (LOWER MIOCENE) SPECIES.

## PELECYPODA.

### Genus LEDA Schumacher.

### LEDA CAHILLENSIS, new species.

Plate XXXIV, fig. 9.

*Description.*—Shell attaining a length of only 6 or 7 mm., width about seven-ninths of length, oval, rounded in front, attenuate behind; well inflated, margin smooth; umbo small, subcentral, turned backward; anterior dorsal margin nearly straight, sloping steeply from umbo; anterior extremity regularly rounded; posterior dorsal margin concave, prominently excavated behind umbo; posterior extremity very attenuate; surface sculptured by numerous, equal, rounded concentric ribs, separated by moderately wide impressed lines; a trace of a poorly developed carina extending from the umbo to the posterior extremity is discernible in the type.

*Dimensions.*—Length, 6.5 mm.; latitude, 4.8 mm.; diameter of single valve, 1.9 mm.

*Notes.*—This gibbous little *Leda* is easily distinguished from associated fossil forms by its small size, great convexity, broad outline, sharply attenuate posterior extremity, excavated margin posterior to umbo, and rather coarse sculpture. It resembles *L. acuta* Conrad (recent) in size but is relatively broader and more excavated behind. Distinguishable from the closely allied *L. taphria* Dall by much smaller size, more excavated dorsal posterior margin, and finer concentric sculpture.

Named for Cahill Ridge, west of Redwood City, on the flanks of which is the type-locality.

*Type.*—L. S. J. U., No. 1065. (Locality No. 57.)

*Horizon.*—Vaqueros formation, Lower Miocene.

*Locality.*—Santa Cruz quadrangle, San Mateo County, locality No. 57, on road to Kings Mountain House, 2 miles west of Woodside, in rather coarse, brownish-yellow sandstone. (W. A. Williams.)

## Genus YOLDIA Moller.

### YOLDIA SUBMONTEREYENSIS, new species.

Plate XXXIV, fig. 8.

*Description.*—Shell attaining a length of 32 mm., width about two-thirds of length, oblong, rounded in front, somewhat attenuated, angular, and slightly gaping behind, compressed; margin smooth; umbo central; anterior dorsal margin nearly straight, anterior extremity broad and evenly rounded; posterior dorsal margin concave, curving upward at posterior extremity, but not prominently excavated immediately in rear of umbo; basal margin curving up sharply behind and meeting dorsal margin in a right angle, although the extreme end is slightly posterior to the angle; a faint carina, separated from dorsal margin by impressed line or lunule, extends from umbo to posterior extremity; surface sculptured by numerous regular, narrow, incremental lamellæ, which are abruptly truncated on the edge toward the umbo, slope off gently on the side toward the periphery, and become narrower posteriorly.

*Dimensions.*—Length, 32 mm.; latitude, 21 mm.; diameter of single valve, 2.5 mm.; umbo to anterior extremity, 17 mm. (53 per cent of longtitude).

*Notes.*—This species is characterized by its size, the central position of the umbones, rather broad, slightly rounded, gaping posterior extremity and regular concentric lamellæ. It is closely allied to *Leda whitmani* Dall (possibly a *Yoldia*) from the Miocene of Oregon, but differs from it in being less attenuate posteriorly and broader in outline; the excavation behind the umbo in the latter is also more pronounced than in *Y. submontereyensis.* It is smaller and less attenuated posteriorly than *Y. oregona* Shumard; is much smaller and much longer, but narrower posteriorly, than *Y. cooperi* Gabb from the Pliocene to Recent fauna; and is much larger, broader and more closely sculptured than *Y. impressa* Conrad from the Oligocene and Miocene. Distinguished from *Y. supramontereyensis*, new species, which occurs in the Miocene above the Monterey, by its shorter and broader posterior end.

Name derived from its stratigraphic position in the lower Miocene below the Monterey (middle Miocene) formation.

*Type.*—Cat. No. 165459, U.S.N.M. (Locality 35.)

*Horizon.*—Vaqueros formation, lower Miocene.

*Localities.*—Santa Cruz quadrangle, San Mateo County, localities Nos. 1 and 2, on hill and beside road, respectively, three-fourths mile northeast of north end of Searsville Lake (R. Arnold); locality No. 35, on San Francisquito Creek, just below dam, 1¼ miles southwest of Stanford University (R. Arnold; Fay).

## Genus GLYCYMERIS Da Costa.

### GLYCYMERIS BRANNERI, new species.

Plate XXXIV, fig. 1.

*Description.*—Shell averaging nearly 70 mm. in length, about as wide as long, suborbicular, equivalve, bilaterally unsymmetrical, considerably convex for one of this genus, thick and heavy; umbo somewhat anterior to center, protruding beyond hinge line and turned slightly toward the front; anterior dorsal margin straight, sloping steeply from umbo; anterior extremity quite sharply rounded, and located above center line of shell; posterior dorsal margin straight, sloping less steeply than anterior; posterior extremity protruding obliquely downward and backward, regularly rounded, located below center line of shell; posterior dorsal and ventral margins join in a faintly defined angle considerably above and in front of the extreme end of the shell. Surface sculptured by numerous flat to concave-topped, close-set, radiating ribs (about 55 discernible in the type), relatively much broader toward the middle of the shell and becoming narrower and less well defined toward either end; in the later stages of growth a raised beaded intercalary line occupies the interspace and (in the type) rises above the level of the ribs; prominent incremental lamellæ cross the ribs, bowing convexly upward toward the umbo; they are straight on the sides and across the top of the ribs, and become less prominent and more closely set toward the periphery in the adult shell. Hinge with 5 or 6 boomerang-shaped teeth, with angle toward the umbo, on either side of a centrally divaricately striated broad ligamental area; the teeth in the young form a semicircle below and extending on either side beyond the ligamental area.

but in the later stages of growth the centrally situated teeth are obliterated by encroachment of the ligament. Interior unknown, but interior of margins appear to be smooth.

*Dimensions.*—Length, 62 mm.; latitude, 62 mm.; diameter of single valve, 23 mm.

*Notes.*—This magnificent species is apparently one of the largest of the west coast forms, equaling in size but not in convexity the Cretaceous *Glycymeris veatchii* Gabb and its Eocene variety *G. veatchii major* Stanton. It also lacks the prominent groove which separates the dorsal posterior angle from the rest of the shell in the earlier forms. It is distinguishable from *Glycymeris gabbi* Dall from Coos Bay, Oregon, the next largest Miocene species, by its unsymmetrical outline, its much greater size, relatively greater convexity, closer set ribs, and peculiar wavy incremental sculpture. The species is believed to be characteristic of the Vaqueros formation (lower Miocene).

Named in honor of Dr. John Casper Branner, professor of geology, Leland Stanford Junior University.

*Type.*—Left valve, Cat. No. 165455, U.S.N.M. (Locality No. 12.)

*Horizon.*—Vaqueros formation, lower Miocene.

*Localities.*—Santa Cruz quadrangle, San Mateo County, locality No. 12, Mindego Creek, 1 mile above its confluence with Alpine Creek. (R. Arnold, H. Holly, L. C. Mills.)

## Genus CARDIUM (Linnæus) Lamarck.

### Subgenus TRACHYCARDIUM Morch.

### CARDIUM (TRACHYCARDIUM) VAQUEROSENSIS, new species.

Plate XXXIV, fig. 3.

*Description.*—Shell attaining a length of over 100 mm., nearly as high as long, subcircular in outline, very convex, quite thick; umbo prominent, protruding above hinge-line, subcentral, turned slightly toward anterior extremity; anterior extremity regularly rounded, posterior one somewhat flattened, forming two faint angles, the lower one of which is connected with the umbo by quite a pronounced angle in the surface of the shell, upper angle about two-fifths length of shell from the umbo. Sculpture consists of about 34 tall, squarish ribs separated by deep channeled interspaces about equal in width to the ribs; the ribs become less and less conspicuous toward the ends of the shell; incremental sculpture well developed, and making a convex bow upward toward the umbo on top of each rib. Hinge and interior probably similar to *C. quadrigenarium.*

*Dimensions.*—Length, 65 mm.; altitude, 60 mm.; diameter of single valve, 29 mm.

*Notes.*—This species is doubtless the precursor of *C. quadrigenarium* Conrad, from the Pleistocene and Recent fauna, but differs from the latter in being bilaterally more symmetrical on account of being less produced in the ventro-posterior region, having only about three-fourths as many ribs (34 instead of about 45), having narrower, steeper sided ribs and a more prominent angle extending from umbo to posterior extremity. It differs from *C. quadrigenarium* Conrad, var. *fernandoensis* Arnold, from the lower Pliocene, by being much larger, more convex, having more prominent umbones, and having fewer, wider, deeper, steeper-sided interspaces. Named for the Vaqueros formation, of which it is believed to be characteristic.

*Type.*—Imperfect right valve, Cat. No. 165457, U.S.N.M. (Locality No. 12.)

*Horizon.*—Vaqueros formation, lower Miocene.

*Localities.*—Santa Cruz quadrangle, San Mateo County, locality No. 12, Mindego Creek, 1 mile above its confluence with Alpine Creek. (R. Arnold, H. H. Holly, L. C. Mills.)

## GASTEROPODA.

### Genus AGASOMA Gabb.

### AGASOMA SANTACRUZANA, new species.

Plate XXXIV, fig. 7.

*Description.*—Shell attaining a length of at least 40 mm., pyriform; spire short and small compared with body whorl, consisting of 4 to 5 whorls; upper whorls convex, minutely cancellated by about 4 spiral and numerous less prominent axial, sharp, raised lines; body whorl surmounted by a prominent outwardly expanding carina carrying 14 or 15 unequal, irregularly placed, rounded, raised tubercles; between the carina and the suture there is an irregular cord-like sutural ridge the plications of which are smooth except for microscopic incremental lines; whole surface of body whorl sculptured by numerous fine raised lines which usually alternate in size and increase in prominence toward the base; occasional lines of interrupted growth and numerous very fine incremental lines also cross the body whorl. Aperture pyriform; canal narrow; lip simple.

*Dimensions.*—Of type from which portion of canal is missing, length, 26 mm.; latitude, 17.5 mm.

*Notes.*—This species is allied to *Agasoma barkerianum* Cooper,[a] *Agasoma gravida* (Gabb), and *Agasoma sinuata* (Gabb), the first two from the Vaqueros (lower Miocene), the last from the upper Miocene of Walnut Creek, Contra Costa County. It differs from the first in having a lower spire, a broader but less sharply nodose carina on body whorl, and in lacking the prominent nodose angles on the middle of the body whorl; it differs from the second in having a lower spire and in having a carinated body whorl, but no angles on body whorl; it differs from the last in being much broader and in having less prominently sculptured upper whorls, although it resembles the last in the prominence, width, and general character of its carina. Poorly preserved specimens from locality 12, which have been assigned to *A. santacruzana*, show faint indications of two or three rather prominent raised lines on the body whorl, somewhat similar to but very much less prominent than the nodose revolving ridges on the middle of the body whorl in *A. barkerianum* Cooper. With the exception of *A. sinuata* Gabb and *A. stanfordensis*, new species, which occur in the upper Miocene, all of the members of this genus on the west coast are believed to be confined to the lower Miocene or "Agasoma zone" of Merriam.[a]

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[a] Bull. California State Min. Bur., No. 4, p. 53, pl. v, fig. 63, 1894.

Named for the Santa Cruz quadrangle.

*Type.*—Slightly imperfect young specimen, L. S. J. U., No. 1072. (Locality No. 1.)

*Horizon.*—Vaqueros formation, lower Miocene.

*Localities.*—Santa Cruz quadrangle, San Mateo County, locality No. 1, on hill north of road, one-half mile north-northeast of the north end of Searsville Lake; locality No. 12, Mindego Creek, 1 mile above its confluence with Alpine Creek (R. Arnold); also found at U. S. Geological Survey locality No. 4631, 10 miles north of Coalinga, Fresno County. (R. Arnold, Jas. H. Pierce.)

## MONTEREY (MIDDLE MIOCENE) SPECIES.

## PELECYPODA.

### Genus VENERICARDIA Lamarck.

### VENERICARDIA MONTEREYANA, new species.

Plate XXXV, fig. 4.

*Description.*—Adult shell attaining a length of at least 10 mm., width about three-fourths of length, suboval in outline, compressed; umbones near anterior extremity, small, turned toward the front; anterior extremity short, regularly rounded; posterior extremity long, obliquely projected below, quite sharply rounded; surface sculptured by about 22 moderately broad radiating ribs and numerous subequally spaced concentric lines, radiating and concentric systems together giving a cancellate appearance.

*Dimensions.*—Length, 10 mm.; altitude, 7 mm.; diameter, 1 valve, 1+ mm.

*Notes.*—This species is probably allied to *V. barbarensis* Stearns and *V. ventricosa* Gould. It has more anterior umbones and has more numerous ribs (22 instead of 18) than the former, and is much flatter than the latter; its concentric sculpture is also more prominent than that in either of the recent species. Owing to the distortion of all the specimens of *V. montereyana* it is impossible to say with certainty just what its original outline was, but it is believed to have been about as shown in the figured type.

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[a] Bull. Dept. Geol., Univ. of California, III, 1904, p. 377 *et seq.*

*Type.*—Cat. No. 165464, U.S.N.M.

*Horizon.*—Monterey shale, middle Miocene.

*Locality.*—Santa Cruz quadrangle, Santa Cruz County, locality No. 121, on Newell Creek, 1½ miles north of its confluence with San Lorenzo River. (J. F. Newsom, R. Arnold.)

## Genus MACTRA Linnæus.

### MACTRA MONTEREYANA, new species.

Plate XXXV, fig. 2.

*Description.*—Shell attaining a length of at least 30 mm., width a little more than one-half length, subtrigonal, compressed, subequivalve, inequilateral; umbones a little behind middle, small, turned slightly forward; anterior margin considerably longer than posterior; very gently convex; anterior extremity quite sharply angulated below; a faintly developed carina or angle, most prominent near umbo, extends from the latter to the anterior extremity; base only very gently rounded; posterior dorsal margin nearly straight, sloping only moderately steeply, posterior extremity regularly rounded and situated nearly midway between base and umbo; surface sculptured by numerous fine incremental lines and numerous obsolete short undulations.

*Dimensions.*—Length, 31 mm.; latitude, 18 mm.; diameter single valve, 2+ mm.; angle between dorsal margins, 130°.

*Notes.*—This species may be distinguished from all others of the same genus from the west coast by its great relative length and long, attenuated anterior extremity. It is very closely allied to *M. dolabriformis* Conrad of the recent Lower California fauna, but may be distinguished from the latter by its relatively greater length, less steeply sloping posterior dorsal margin, more central posterior extremity, and more attenuated anterior end. Considering the fact that all of the specimens of *M. montereyana* so far examined have been subjected to at least slight deformation by stresses within the containing shales, the separation of *M. montereyana* from *M. dolabriformis* is attended with some uncertainty.

*Type.*—Cat. No. 165463, U.S.N.M.

*Horizon.*—Monterey shale, middle Miocene.

*Locality.*—Santa Cruz quadrangle, Santa Cruz County, locality No. 122, on Love Creek, 1 mile above its confluence with San Lorenzo River. (J. F. Newsom, R. Arnold.)

## UPPER MIOCENE SPECIES.

## PELECYPODA.

### Genus YOLDIA, Moller.

### YOLDIA SUPRAMONTEREYENSIS, new species.

Plate XXXV, fig. 9.

*Description.*—Shell attaining a length of 32 mm., width about two-thirds length, oblong, rounded in front, somewhat attenuated, angular and slightly gaping behind, compressed; margin smooth; umbo not prominent, curving backward, anterior, being about 48 per cent of the length of the shell from the exterior extremity; anterior dorsal margin slightly convex, anterior extremity quite evenly rounded; posterior dorsal margin slightly concave and turned up at the extremity, meeting the ventral margin in a right angle slightly above and anterior to the curved extremity; a very faint carina, separated from the dorsal margin by a faint groove, extends from the umbo to the posterior extremity. Surface sculptured by numerous, regular, narrow, incremental lamellæ, as in *Y. submontereyensis*, new species. Hinge and teeth similar in a general way to *Y. cooperi*. (See note following description of *Y. submontereyensis*, p. 376.)

*Dimensions.*—Length, 37 mm.; latitude, 20.2 mm.; umbo to anterior extremity, 18 mm. (48 per cent of length).

*Notes.*—This species is characterized by its long posterior extremity, which has a relatively greater length than that of any of the other west coast species. *Y. supramontereyensis* is closely allied to *Y. submontereyensis*, new species from the lower Miocene, but is easily distinguishable by its long posterior extremity.

Name derived from its stratigraphic position in the upper Miocene above the Monterey (middle Miocene) formation. This species occurs in the bed overlying the basalt flow near Stanford University.

*Type.*—L.S.J.U., No. 1067. (Locality No. 4.)

*Horizon.*—Upper Miocene.

*Localities.*—Santa Cruz quadrangle, Santa Clara County, locality No. 4, in "Tusk Gully" near road, 2½ miles south of Mayfield; locality No. 42, on west face of hill facing road, one-half mile west of locality No. 4. (R. Arnold.)

### Genus PERIPLOMA Schumacher.

### PERIPLOMA SANCTÆCRUCIS, new species.

Plate XXXV, fig. 8.

*Description.*—Shell attaining a length of 40 mm., width nearly five-eighths of length, oblong, inequivalve, inequilateral, anterior end rounded, posterior shorter and more contracted; right valve gibbous, left only slightly convex; shell material somewhat nacreous, this character persisting in the type of the species; beaks small, bent only slightly toward the posterior extremity; anterior dorsal margin nearly parallel with base, rounds off gradually into anterior extremity; posterior dorsal margin straight, forming an angle of about 140° with the anterior margin; posterior extremity somewhat angularly truncated. An internal rib extends from umbo to posterior ventral angle, this rib being reflected as a groove in that portion of the type specimen which is preserved as a cast. A peculiar substratum of the shell is rather minutely radially striated, and this radiation is exaggerated by erosion on the type. Surface sculptured by numerous unequal but faint concentric undulations and fine incremental lines. Hinge similar to *P. argentaria* Conrad.

*Dimensions.*—Length, 40 mm.; anterior extremity to beak, 25 mm.; latitude, 24 mm.; diameter, right valve, 7 mm.; left valve, 5 mm.

*Notes.*—This species is closely allied to *P. argentaria* Conrad, from the recent fauna of California, and is probably the latter's precursor. It is narrower and much more produced posteriorly, has the umbo less prominently bent toward the rear, and apparently has the radial striations in the substratum of the shell better developed than does *P. argentaria.*

Named for the Santa Cruz quadrangle.

*Type.*—L. S. J. U., No. 1074.

*Horizon.*—Probable equivalent of Merriam's "Contra Costa Miocene," basal upper Miocene.

*Localities.*—Santa Cruz quadrangle, Santa Clara County, locality No. 42, in soft sandstone on hill on the east side of Madera Creek, 2½ miles southwest of Mayfield. (R. Arnold, J. C. Branner.)

## GASTEROPODA.

### Genus FUSUS Lamarck.

### Subgenus PRISCOFUSUS Conrad.

### FUSUS (PRISCOFUSUS?) STANFORDENSIS, new species.

Plate XXXV, fig. 7.

*Description.*—Shell attaining a length of 45 mm., rather broadly fusiform; apex acute; whorls 5 or more, regularly and prominently convex; upper whorls obsoletely spirally striate; sutural riblet at the upper margin of the whorl well developed; body whorl plump, faintly angulated in middle, spirally sculptured by numerous (8 or 9 above angle) revolving major ribs, between each pair of which is a lesser rib; about 16 or 18 very faint varices cross the whorl and rise to faint nodes on the angle; surface sculptured also by fine incremental lines; suture distinct, wavy. Aperture broadly ovate; canal moderately narrow, rather short, straight.

*Dimensions.*—Length, 40 mm.; latitude, 25 mm.; apical angle about 63°.

*Notes.*—This species is distinguished from other members of the genus in associated formations by its broad form. In general outline it resembles *Priscofusus corpulentus* Conrad from the Oligocene-Miocene of Astoria, Oregon, but has more regularly rounded, less angulated whorls and apparently more prominent spiral sculpture.

*Type.*—A well-preserved cast in soft sandstone, L. S. J. U., No. 1081.

*Horizon.*—Upper Miocene, above basalt flow.

*Locality.*—Santa Cruz quadrangle, Santa Clara County, locality No. 42, near Frenchman's Tower, on hill between Tusk Gully and Madera Creek, 2½ miles south-southwest of Mayfield. (J. C. Branner, R. Arnold.)

### Genus AGASOMA Gabb.

#### AGASOMA STANFORDENSIS, new species.

Plate XXXV, fig. 5.

*Description.*—Shell attaining a length of at least 60 mm., broadly pear-shaped, body whorl large as compared with the spire, which is depressed-conical; whorls 4, convex, the three upper ones almost enveloped; exposed portion of the upper whorls spirally sculptured; body whorl large, plump, biangular; surface between angle and upper suture convex, sloping at angle of about 30°; sides nearly flat; upper angle ornamented by about 10 unequally spaced unequal axially elongated nodes; lower angle similarly sculptured except that the nodes are weaker but considerably longer and become obsolete only a short distance below the middle of the space between the two angles; spiral sculpture consists of about 11 or 12 quite prominent, widely and almost equally spaced wide raised lines, in the spaces between which are several alternating raised lines of less importance; suture appressed, distinct. Aperture subovate; lips simple; canal moderately long and recurved.

*Dimensions.*—Of type from which the canal has been broken, length, 55 mm.; latitude, 50 mm.; apical angle about 106°; spire, 5+ mm.

*Notes.*—This species is closely allied to and probably the direct descendant of *A. kernianum* Cooper from the Vaqueros or lower Miocene formation. It may be distinguished from the latter by its usually much larger size, wider and more sloping space between suture and upper angle, and less prominent but longer nodes on the lower angle. The details of spiral sculpture are quite similar on the two species, but coarser in *A. stanfordensis*. Both the type and the fossil from San Diego, which may be the same species, the only two specimens extant, are casts; details of the sculpture are therefore unobtainable at present.

*Type.*—Internal cast, lacking canal; L. S. J. U., No. 1087, locality No. 4.

*Horizon.*—Miocene above and later than the basalt flow; this horizon believed to be the equivalent of the "Contra Costa County Miocene" of Merriam, which is above the Monterey (middle Miocene).

*Localities.*—Santa Cruz quadrangle, Santa Clara County, locality No. 4, in ravine beside county road, 2½ miles south of Mayfield (R. Arnold); ? also found in the San Diego formation, lower Pliocene, on mission grade midway between the head of Sixth street and the old County Hospital at San Diego (Mrs. Kate Stephens).

## PURISIMA AND MERCED (UPPER MIOCENE AND PLIOCENE) SPECIES.

## GASTEROPODA.

### Genus FUSUS Lamarck.

### Subgenus BUCCINOFUSUS Conrad.

### FUSUS (BUCCINOFUSUS) PORTOLAENSIS, new species.

Plate XXXVII, fig. 8.

*Description.*—Shell attaining a length of at least 60 mm., fusiform, moderately slender; apex acute, whorls 7 or more, very convex, slightly compressed above near suture; nuclear whorls unknown; the next four crossed by 9 very broad, prominent, rounded varices extending from lower suture to upper revolving sutural ridge; interspace between varices deep and V-shaped; about 8 sharply defined, rounded, revolving ribs (between each pair of which on the lower whorls is often a small intercalary) occur on each whorl in addition to the sutural rib which is more prominent than the others; whole surface crossed by numerous small incremental lines; body whorl quite regularly convex, projected into a long, slightly outward-curving pillar; varices obsolete, or nearly so, on the body whorl, and also on the penultimate whorl on the larger specimens, as in *F. barbarensis* Trask; suture distinct, wavy. Aperture elongate-elliptical; outer lip internally striate; inner lip smooth gently concave; canal rather long, narrow, curved outward toward anterior extremity.

*Dimensions.*—Length, 62 mm.; latitude, 31 mm.; longitude of body whorl, 44 mm.; longitude aperture and canal, 34 mm.; apical angle about 49°.

*Notes.*—This species, which is very abundant at the Portola locality, is quite closely related to *F.* (*Buccinofusus*) *coosensis* Dall, from the Empire beds (upper Miocene) of Coos Bay, Oregon, but may be distinguished from the latter by its smaller size, less prominently posteriorly angulated whorls, much broader axial varices, more regular spiral sculpture, which consists of 9 major ribs covering the whole whorl instead of 9 more or less irregular ribs which extend only to the angle and are then replaced by obsolete spiral striæ on the upper part of the whorl; sutural riblet also better defined in *F. portolaensis*. *F. portolaensis* differs from *F. arnoldi* Cossmann, 1903, (+ *rugosus* Trask, 1855, not of Lamarck), *F. robustus* Trask, *F. kobelti* Dall, and other late Tertiary or Quaternary species from the west coast by its much broader, rounded spiral lines and less rugose incremental sculpture.

Named for the village of Portola, near which the species is found abundantly.

*Type.*—Cat. No. 165473, U.S.N.M. (U.S.G.S. locality No. 4665.)

*Horizon.*—Purisima formation (upper Miocene portion).

*Localities.*—Santa Cruz quadrangle, San Mateo County, locality No. 6, on Sausal Creek, one-half mile southwest of Portola (J. P. Smith, R. Arnold, and others); also occurs at about the same horizon at several localities in eastern Monterey County and western Fresno County (Homer Hamlin, R. Arnold); type-locality, U. S. Geological Survey No. 4635, Etchegoin (upper Miocene or lower Pliocene) formation, White Creek, 19 miles northwest of Coalinga, Fresno County.

## Genus CHRYSODOMUS Swainson.

### CHRYSODOMUS STANTONI, new species.

Plate XXXVII, fig. 4.

*Description.*—Shell often attaining a length of 100 mm., broadly fusiform, moderately thin; spire well elevated; apex acute. Whorls 5 or 6; nuclear whorls unknown; others tabulate and sharply angulated about one-third the width of the whorl from the posterior margin; surface of whorls below angle, slightly convex, nearly vertical, ornamented by several wide spaced obsolete revolving ribs which are closer set and slightly better developed toward the base of the body whorl; revolving table convex, sloping at about 30° from the horizontal, bounded by two raised lines or narrow ridges, the one nearest the suture being the more prominent and separated from the latter by a deep channeled sutural groove; whole surface ornamented by faint superficial revolving lines and by numerous fine incremental lines which extend posteriorly from the suture across the revolving table and then descend vertically to the suture below. Aperture broadly ovate, narrowing in front to a moderately broad, short canal which is equal in length to about one-fourth the length of the aperture, is almost as wide as long, and has a concave extremity which is slightly reflexed; outer lip simple; inner lip smooth; pillar narrow, slightly twisted, very feebly plaited externally, and sculptured by broadly waved incremental lines.

*Dimensions.*—Length (of slightly decolleté type), 90 mm.; latitude, 45 mm.; length body whorl, 62 mm.; length aperture, 44 mm.; length canal, 11 mm.; latitude canal, 8.5 mm.

*Notes.*—This beautiful species is characterized by its peculiarly tabulated whorls, deep channeled sutural groove, and obsolete spiral sculpture. It bears a striking resemblance to *Ancistrolepis magnus* Dall, from the recent fauna of the north Pacific, but may be distinguished from the latter by its much longer, narrower canal.

*C. stantoni* is quite different from *C. postplànatus* Dall from the upper Miocene of the Bogachiel River, Clallam County, Washington, being distinguishable by its sutural canal, more sloping table, and obsolete instead of well defined spiral sculpture.

It is apparently characteristic of the upper part of the Purisima and lower portion of the Merced formations, where it is usually not rare.

The species is named in honor of Dr. Timothy W. Stanton, chief paleontologist, United States Geological Survey, whose work on the Mesozoic faunas is well known.

*Type.*—Cat. No. 165475, U.S.N.M. (Locality No. 139.)

*Paratype.*—L. S. J. U., No. 1088. (Locality No. 139.)

*Horizon.*—Upper Purisima and lower Merced formations, Pliocene.

## LOCALITIES.

*Purisima formation (lower Pliocene portion).*—Santa Cruz quadrangle, San Mateo County, locality No. 139, Purisima Rock, seven-eighths mile east of Año Nuevo Point (R. Arnold, W. R. Hamilton); locality No. 141, sea cliffs between the mouths of Tunitas and Pescadero creeks. (J. P. Smith, G. H. Ashley, R. Arnold, J. F. Newsom, and others.)

*Merced formation, upper Pliocene.*—Santa Cruz quadrangle, San Mateo County, locality No. 140, sea cliffs, immediately east of mouth of Año Nuevo Creek, 2 miles east of Ano Nuevo Point (R. Arnold); also at locality A 11, in sea cliff, west of Capitola, Santa Cruz County, immediately east of the Santa Cruz quadrangle (G. H. Ashley, R. Arnold).

## Genus THAIS Link.

### THAIS TRANCOSANA, new species.

Plate XXXVI, fig. 3.

*Description.*—Shell attaining a length of 26 mm., subovate, a little longer than wide, very thick, heavy; spire elevated; apex acute; whorls 4 or more, very slightly convex, increasing rapidly in size from apex downward; surface smooth except for an obsolete sculpture of 3 or 4 revolving lines; body whorl much larger and more convex than others, regularly rounded, its surface ornamented by about 13 obsolete revolving ridges. Aperture elongate-elliptical; outer lip thickened and dentate internally, four teeth visible in the type; back of each tooth an internal revolving line; inner lip broad and smooth; canal short, narrow and oblique.

*Dimensions.*—Of decolleté type, length (restored), 27 mm.; latitude, 19 mm.; length body whorl, 21 mm.; length aperture and canal, 16 mm.; latitude aperture, 5 mm.

*Notes.*—The type exhibits a broad sinus or groove in the inner lip beginning at the middle and extending to the posterior extremity of the aperture. Doctor Dall suggests that the groove may have been worn in the lip by a hermit crab, as often happens in the case of recent shells, and from the appearance of the groove such an explanation seems well founded. The species is quite different from any of the known west coast recent or fossil forms of this genus, being characterized by its exceedingly heavy shell, straight-sided conical spire, and obsolete revolving ridges.

Named after Los Trancos Creek, near which the type was found.

*Type.*—A decolleté specimen, L. S. J. U., No. 1082.

*Horizon.*—Merced formation, upper Pliocene.

*Locality.*—Santa Cruz quadrangle, Santa Clara County, locality No. 21, ditch between Feld Lake and Los Trancos Creek, 2½ miles south-southwest of Stanford University. (T. J. Hoover, R. Arnold.)

## Genus CHLOROSTOMA Swainson.

### CHLOROSTOMA STANTONI Dall, var. LAHONDAENSIS, new variety.

Plate XXXVI, fig. 2.

*Description.*—Shell attaining an altitude of 25 mm.; conoidal, much broader than high, umbilicated; whorls 5, angulate near base, upper surface sloping steeply, very gently concave both above and below a slightly raised line which revolves about two-fifths the distance from the suture to the angle; a second similar line revolves close to and just below the suture, and a much more prominent one adorns the angle of the whorl; body whorl biangular, the surface between the angles concave, almost vertical, and being about equal in width to the distance between the sutural revolving line and the next line below; the upper angle is compressed into a raised line, while the lower angle is simply the junction between the convexly curved base and the concave, nearly perpendicular surface of the interangular space; obsolete spiral lines are sometimes present on the upper surface of the whorls, especially near the suture; base minutely spirally striate; whole surface of whorls marked by numerous fine, posteriorly, downward-sloping, incremental lines; suture appressed, inconspicuous; umbilicus lacking, body whorl not angulate adjacent to it; aperture subcircular, the upper margin extending far in advance of the lower part.

*Dimensions.*—Altitude, 23 mm.; latitude, 30 mm.; apical angle about 80°.

*Notes.*—This variety differs from the typical form, which is from the Empire beds (upper Miocene) of Coos Bay, Oregon, by being relatively broader, less prominently spirally sculptured, and in having the revolving line on the upper surface much less prominently raised and situated above, rather than below the middle of the upper surface; in *C. stantoni* the upper surface is prominently angulated in the middle of the upper surface. The new variety also possesses a revolving rib just below the suture which the typical form lacks.

Named for La Honda, near the type locality.

*Type.*—Decolleté specimen, L. S. J. U., No. 1079.

*Horizon.*—Lower Purisima (upper Miocene portion).

*Locality.*—Santa Cruz quadrangle, San Mateo County, locality No. 150, Pescadero Creek, just above mouth of Jones Gulch, 3 miles due south of La Honda. (J. F. Newsom, R. Arnold.)